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A behavior and cognitive evaluation of the "*Fireworks*" fire ecology curriculum

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A Behavioral and Cognitive Evaluation of the "*FireWorks*" Fire Ecology Curriculum

Presented To

The USDA Forest Service

Rocky Mountain Research Station, Northern Region and the Bitterroot Ecosystem Management Research Project

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This study was designed to evaluate the effectiveness of a fire ecology instructional unit in increasing students' knowledge of fire ecology practices using a multidimensional approach to assessment. The study examined the assertion that a fire ecology program curriculum available as a traveling environmental educational trunk would be effective in promoting knowledge of fire ecology when administered to students in addition to their existing school curriculum.

Ramsey & Hungerford (1989) stated that responsible environmental behavior is the ultimate goal of environmental education but that current empirical studies indicate this goal is not being met in schools across America (p.26). Most recently, empirical studies of various aspects of environmental curricula have been conducted. For example, Lisowski and Disinger (1991) conducted a study focused on the influence of field instruction strategies on student understanding and retention of ecological concepts. They found that gains in conceptual understanding were positively related to instructional emphasis and that field-based programs were effective in fostering student understanding of ecological concepts.

In 1987, Ham and Sewing interviewed teachers to determine the importance of barriers to environmental education. Results indicated that lack of time both in terms of preparation and actual school-day time were the most important barriers to teaching environmental education. Other barriers included lack of specific instructional materials and funding and teachers' concerns about their own competence to teach environmental education. Although most said they were positive about environmental education, the majority demonstrated little commitment to actually teach it.

Roy, Petty and Durgin (1997) conducted a nationwide study examining the use of traveling boxes as a tool for environmental education. The self-contained, portable environmental education "boxes" were suggested as a new tool to assist teachers in eliminating some of the barriers mentioned by Ham & Sewing (1987) and were found to be effective in education of environmental concepts. Their study indicated that the use of traveling environmental educational trunks or boxes was on the increase in many parts of America but suggested that research was needed to examine effectiveness.

In 1995, the USDA and USDI recommended that "...a clear message about the important role of fire as a natural process" and an "understanding of policies concerning wildland fire and the urban interface" be communicated to the general public (Federal Wildland Fire Management Policy & Program Review, p. 12). In response, *FireWorks*: Curriculum and Trunk was prepared in 1997 by the USDA Forest Service in conjunction with the Rocky Mountain Research Station, Northern Region and the Bitterroot Ecosystem Management Research Project (Appendix I).

FireWorks has two educational objectives, one of which is increasing student understanding of fire as a natural process and of forest management policy regarding wildland fire and urban interface. The second is increasing student skills generally associated with science or math curricula.

An empirical evaluation of the effectiveness of the *FireWorks* curriculum in meeting these goals was undertaken and is described herein. The evaluation of increased student understanding involved knowledge: a) of the physical science of combustion, especially in the wildland fuels; b) that a forest has many kinds of

plants and animals, which change over time and influence one another; c) that fire is an important natural process in many forest ecosystems; d) that native plants and animals have ways to survive fire, to reproduce, or both after fire; e) that people influence fire-dependent wildlands in the areas where they live; and f) that people respond in different ways to fire-related questions.

The evaluation of the curriculum in terms of skills acquired as part of the hands-on learning incorporated in each lesson required assessment of children: a) observing; b) describing those observations; c) stating hypotheses; d) explaining reasoning; e) classifying information; f) identifying and expressing responses to fire-related questions; g) working in teams to solve problems; h) measuring, counting, and computing; and i) engaging in critical listening and reasoning.

To evaluate the overall effectiveness of the project, a behavioral approach was selected in which students demonstrated knowledge and skills in pre-selected forest sites beyond the classroom walls. Additionally, more cognitively oriented pre- and post-tests were administered just prior to and immediately following the administration of the *FireWorks* curriculum.

We used seventh graders because the curriculum was designed for grades six through nine, because all of the volunteer teachers taught seventh graders, and because the teachers volunteering comparison groups also taught seventh graders. Additionally, sixth graders in two of the volunteer school districts annually participated in an outdoor experience that included some fire ecology. In order to have some time between that outdoor experience and the *FireWorks* project and to

avoid a possible confound, seventh graders, representative of the middle range of adolescent cognitive development, were chosen as the best fit for this evaluation.

Armstrong & Impara (1991) suggested that: 1) the evaluation of curricular effectiveness may be compromised by requirements to teach a curriculum; 2) the more naturalistic the setting, the more reliable the results will be when measuring effectiveness; and 3) that teachers forced to use materials may be uncooperative. To avoid mandatory program use that could skew the evaluation, all teachers participating in the evaluation of *FireWorks* were volunteers, and were allowed to implement the curriculum in unique individual styles.

Because random assignment of classrooms to control groups was not possible, two "comparison groups" (Cook & Campbell, 1979) also participated in the forest sites field-tests and the pre- and post-tests in order to provide a baseline from which to evaluate the effectiveness of treatment.

There were also in-class observations of teachers, students and the interactions between them. In-class observations were used to determine differential use of materials by the teachers and differing degrees of students' hands-on experience with the general classroom curriculum. Observations included both time sampling and event sampling and involved the use of standardized rating scales and checklists. Finally, the degree of involvement with the *FireWorks* curriculum by each teacher was evaluated.

Hypotheses

The study investigated three hypotheses.

1. With respect to skill demonstration in a structured field setting, it was predicted that those students in the *FireWorks* group would demonstrate more knowledge in a field-based test than students who were not exposed to the *FireWorks* curriculum.

2. With respect to fire ecology knowledge, it was predicted that seventh-grade students who were administered the *FireWorks* curriculum would show a greater gain in knowledge from pre- to post-test than seventh graders who were not administered the *FireWorks* curriculum.

3. Finally, it was predicted that seventh graders who had received the *FireWorks* curriculum would, it terms of perception of the classroom environment, demonstrate more interest and engagement in the classroom than the seventh graders who did not receive the *FireWorks* curriculum.

Method

Participants

Schools. Three school districts participated in the evaluation of the *FireWorks* curriculum. They represented one urban school district, one semi-urban school district and one rural school district in western Montana.

Seven classrooms from three schools in the urban district volunteered to participate in either the *FireWorks* (n=5) or the non-treated comparison groups (n=2). Both the rural school district and the semi-urban district each had one school with three classrooms that received the *FireWorks* curriculum (n=6). No comparison groups came from either the rural or semi-urban district.

Students. A total of 313 seventh-grade students participated in the study (treatment group n = 261; comparison group n = 52). A total of 23 special education students mainstreamed into the science classroom were included in the total number of participating students. Table 1 shows the numbers of students by classroom participating in the study.

Teachers. Three teachers from the urban district, two male and one female, volunteered to participate in the evaluation. All three had equivalent teaching experience in terms of number of years (more than 10 years). The comparison groups (n = 2), both from the urban district, had a male teacher in one classroom and a female teacher in the other classroom. The female teacher also taught two classrooms of the treatment group. The second male teacher in the urban district taught three classrooms of treatment group. Additionally, one comparison group and one treatment group from the urban classrooms had student teachers who did not teach the *FireWorks* curriculum and so were not evaluated in terms of classroom environment.

In the semi-urban district, the curriculum was divided between two teachers, a first year science teacher and a 10-year-veteran social studies teacher (both female). The rural school had one female teacher, in her first year of teaching science.

Thus, in terms of gender balance and years of experience, there was some imbalance among among the teachers. Four of the teachers participating in the evaluation were female while only two were male. Two female teachers with at least 10 years of experience and two female teachers with only one year of teaching

experience presented the *FireWorks* curriculum. However, no first year male teacher participated and only one male teacher with at least 10 years of teaching experience presented the *FireWorks* curriculum. The two comparison groups were taught by teachers of equal teaching experience, greater than 10 years, one of each gender.

Table 1

Summary distribution of student participants classified by district, classroom and experimental group.

Urban District	**Semi Urban District**	**Rural District**
School #1	School #1	School #1
1 Male Teacher	2 Female Teachers	1 Female Teacher
Classroom	Classroom	Classroom
TX - #A n=26	TX - #A n=25	TX - #A n=22
TX - #B n=25	TX - #B n=29	TX - #B n=15
TX - #C n=27	TX - #C n=26	TX - #C n=19
Total students = 78	Total students = 80	Total students = 56
School #2		
1 Female Teacher		
Classroom		
TX - #A n=25		
NO - #B n=26		
TX - #C n=22		
Total students = 73		
School #3		
1 Male Teacher		
Classroom		
NO - #A n=26		
Total students = 26		

Note: TX indicates treatment group. NO indicates comparison group.

Instruments

Field Test. Items for the field test were constructed by examining each of the lessons within the *FireWorks* curriculum and creating items based on those lessons. The lessons are divided into seven categories: 1) "Visiting Wildland Fire;" 2) "How Does Fire Work?" 3) "Neighborhood Trees;" 4) "Tough Trees;" 5) "Tree Stories;" 6) "Enlarging the Picture;" and 7) "Dealing with Fire." Each of the lessons within the categories addresses one or more of the *FireWorks'* educational objectives previously listed.

Six sets of five text items, or "tasks," to be responded to at "information stations" in specific parts of the field setting, were created through a content analysis of the *FireWorks* curriculum, with an emphasis on its six objectives. The sets of tasks focused on: 1) Fire Behavior; 2) Shrubs, Herbs, and Pathogens; 3) Tree Taxonomy and Adaptations; 4) Fire History; 5) Homes and Fire; and 6) Lodgepole and Whitebark Pine Forests (Appendix E).

Tasks for Information Station 1, Fire Behavior, were drafted from the *FireWorks* curriculum topics and activities I, II-1, II-2, II-3, IV-1, IV-4, VI, VII, and VII-1, which satisfied the educational objectives of increased student understanding: a) of the physical science of combustion, especially in the wildland fuels; b) that a forest has many kinds of plants and animals, which change over time and influence one another; c) that fire is an important natural process in many forest ecosystems; and f) that people respond in different ways to fire-related questions.

Tasks for Information Station 2, Shrubs, Herbs, and Pathogens, were drafted from curriculum activities III-1, VI, and VI-1, which satisfied the educational

objectives of increased student understanding: b) that a forest has many kinds of plants and animals, which change over time and influence one another; c) that fire is an important natural process in many forest ecosystems; d) that native plants and animals have ways to survive fire or reproduce, or both after fire; f) that people respond in different ways to fire-related questions; and e) that people influence fire-dependent wildlands in the areas where they live.

Tasks for Information Station 3, Tree Taxonomy and Adaptations, were drafted from *FireWorks* curriculum topics and activities III-2, IV, IV-2, and V, which satisfied the educational objectives of increased student understanding: a) of the physical science of combustion, especially in the wildland fuels; b) that a forest has many kinds of plants and animals, which change over time and influence one another; and d) that native plants and animals have ways to survive fire or reproduce, or both after fire.

Tasks for Information Station 4, Fire History, were drafted from *FireWorks* curriculum topics and activities I, II-3, IV-4, V, VI-1, VI-2, and VII-1, which satisfied the educational objectives of increased student understanding: a) of the physical science of combustion, especially in the wildland fuels; b) that a forest has many kinds of plants and animals, which change over time and influence one another; c) that fire is an important natural process in many forest ecosystems; d) that native plants and animals have ways to survive fire or reproduce, or both after fire; and e) that people influence fire-dependent wildlands in the areas where they live.

Tasks for Information Station 5, Homes and Fire, were drafted from *FireWorks* curriculum topics and activities II-3, IV-1, IV-4, V-2, VI, VI-1, VII-1 and

VII-2, which satisfied the educational objectives of increased student understanding: a) of the physical science of combustion, especially in the wildland fuels; c) that fire is an important natural process in many forest ecosystems; e) that people influence fire-dependent wildlands in the areas where they live; and f) that people respond in different ways to fire-related questions.

Tasks for Information Station 6, Lodgepole and WhiteBark Pine Forests, were drafted from *FireWorks* curriculum topics and activities I, III-2, IV-3, V, VI, and VII, which satisfied the educational objectives of increased student understanding: a) of the physical science of combustion, especially in the wildland fuels; b) that a forest has many kinds of plants and animals, which change over time and influence one another; and c) that fire is an important natural process in many forest ecosystems.

After the initial draft of the behavioral tasks was completed, volunteer teachers who had participated in the October, 1997 workshop received a copy with a request for comment or suggestions. All copies were returned with teacher comments, which were evaluated and incorporated into the tasks where appropriate.

The field test with its six sets of tasks was designed for a class of 30 students. The assessment took place in a fairly open, semi-developed setting (basically a campground or picnic area) in two different forest areas chosen because the sites contained the physical environment required to assess knowledge of the *FireWorks* curriculum by the field-test and were in reasonable proximity to the school districts.

Each of the six information stations was staffed by a volunteer "stationmaster" with a list of five tasks for students to perform (see Appendix D). The six stations were marked with large numbered flags so they could be identified from a distance. Each student was issued a punch card with six sections. Generally, more than one classroom went through the field assessment on a given day. Each classroom participating in the study received a different colored punch card. The cards were punched by stationmasters as students completed the station (See Appendix E).

Students worked in teams of five, each team accompanied by a volunteer group leader (adult) who was responsible for getting the team promptly from one station to the next. They were also responsible for collecting each of the punch cards at completion of the six stations.

Pre- and Post-test Cognitive Measure. Multiple-choice, 13-item pre- and post-test exams were constructed from among ten sample questions submitted by each of the volunteer teachers who would be administering the *FireWorks* curriculum. Individual test items submitted were compared with the lesson modules of the *FireWorks* curriculum and used, modified, or discarded depending on how well they mirrored the six domains of the curriculum. Two equivalent forms of the test were constructed. Form A (13 items) was used by all participating classrooms as the pre-test and Form B (13 items) was used by the participating classrooms as the post-test. (see Appendix A for the questions submitted and final Form A and Form B).

Classroom Environment Scale (CES): Form R (Realistic). Felner, Ginter, and Primavera (1982, as cited in Moos & Tricket, 1995) found that in comparison to control students, participants in a primary prevention project for students during transition to high school "saw the school environment as clearer and more structured and reported higher levels of involvement and teacher support (p. 9)." The CES purports to tap dimensions that reflect conditions in which students can learn. It also systematically assesses relationships among students. The scale consists of printed questions with true or false response choices. It contains 90 questions that make up 9 subscales (See Appendix B).

There are three underlying sets of dimensions that the nine subscales measure: 1) relationship dimensions (three subscales); 2) personal growth and goal orientation (two subscales); and 3) system maintenance and change (four subscales).

The three subscales of the relationship dimension are: Involvement, which measures the extent to which students are attentive and interested in class activities, participate in discussions, and do additional work on their own; Affiliation, which measures the friendship students feel for each other; and Teacher Support which measures how much the teacher talks openly with students, trusts them and is interested in their ideas.

The two subscales of the personal growth dimension are: Task Orientation, which examines a teacher's emphasis on completing activities and staying on task; and Competition, which measures how much students compete with each other for grades and recognition and how hard it is to achieve good grades.

The four subscales of the system maintenance and change dimension examine students' perception of classroom structure. Order and Organization focuses on the emphasis placed on student behavior and organization of assignments and activities. Rule Clarity assesses the emphasis on establishing, following a clear set of rules and students knowing consequences for failure to follow those rules, and the amount of teacher consistency of dealing with rule breakers. Teacher Control, or how strict the teacher is in enforcing the rules, in severity of punishment, and in dealing with student infractions is the third subscale. The final subscale in system maintenance is Innovation, described as the extent to which the teacher uses new techniques and encourages creative thinking or allows student contribution in classroom activity planning.

In-Class Observations. Teachers' individual style may affect the classroom climate. Watson (1982), for example, found that teachers establish environments that match their teaching styles. For example, open, nondirective teachers may emphasize teacher support, flexible rules, and innovative instructional procedures, whereas directive teachers create controlled, competitive, and task-oriented classroom environments.

And, of course, students also bring factors into a social group including values, norms, and abilities. Because members of a classroom are brought together in a random manner, every classroom will have a unique blend of characteristics. Moos (1979) found that student characteristics were especially important in influencing teacher control. Because every classroom has its own personality, a teacher may experience control differences between classrooms. Accordingly, the

classroom observation domain set was constructed taking into consideration the nine subscales of the CES as well as the potential interactions between student characteristics and teacher style. There were six domains which are described below.

1) Involvement of Students in Class was defined as the extent to which students are attentive or interested in class activities. A time sampling of number of students "not engaged" (because the number was generally smaller than the number engaged and therefore easier to tally) was conducted for five 10-minute periods during a class period of 50 minutes. The definition of "not engaged" was any off-task behavior, doodling, talking, out-of-seat behavior, throwing objects, or any other disruptive behavior.

2) Involvement of Teacher in Instruction was instruction was defined as the total time from the beginning of actual instruction until its end, not including announcements or other business of the classroom.

3) Order and Organization was divided into two parts, the number of times the teacher reminded students about rules or stopped instruction to correct, and the number of times the students were off task, disruptive or disorderly.

4) Teacher Control rated the teacher on all rule enforcement. The points on the rating scale were 0 = not at all, 1 = mildly, 2 = moderately, 3 = strongly, 4 = severely or harshly. Every infraction that elicited a rule enforcement was rated from 0 to 4 and the numbers summed. The final Teacher Control rating was the average of the infraction ratings.

5) Student's Opportunity to Respond was defined as number of times students were asked questions in order to interact with teacher. Each question from

the teacher where an answer was expected was counted. Rhetorical questions were not counted.

6) Total Number of Students Responding during Class Period was defined as number of students answering, raising hands, shouting to gain teacher's attention, or exhibiting similar behavior.

Activity Checklist. All teachers who presented the *FireWorks* curriculum were given an activity checklist which was divided into eight topics, including Visiting Wildland Fire, How Does Fire Work? Neighborhood Trees, Tough Trees, Tree Stories, Enlarging the Picture, and Dealing with Fire (See Appendix F). Each teacher was asked to indicate if s/he used a particular activity and the approximate classroom time used.

Procedure

On October 16, 1997, the Intermountain Fire Sciences Laboratory, Missoula, Montana conducted a teacher workshop for *FireWorks* for Grades 6-9. The workshop introduced the new curriculum, demonstrated many of the activities that could be used in the classroom, and facilitated a group discussion about possible changes and suggestions. Requests were then made for volunteers to assist the University of Montana in a program evaluation of the *FireWorks* curriculum. Of the 14 teachers representing 6 school districts who were present, six teachers volunteered to pilot the *FireWorks* curriculum in their school following the workshop. The volunteers then scheduled the *FireWorks* traveling box for their classroom for two week time slots.

Each of the volunteer teachers was contacted by phone, an appointment was scheduled to map out details of testing times and observations, a copy of the science curriculum for his/her school collected, and dates were scheduled for his/her receipt of the *FireWorks* trunk. The volunteer teachers were also sent the tentative field task items with requests for input and suggestions for improvement. The teachers were to return the field items with suggestions along with 10 questions that could be used for a paper-pencil pre-post test. All teachers returned their field test items, but only three returned questions for the pre-post tests.

Volunteer teachers began teaching the *FireWorks* curriculum in the classrooms according to his/her scheduled dates. The first school (rural) to teach the curriculum began on March 15, 1998. The urban school and the semi-urban school district began their instruction in either the second week or third week of April, 1998. All schools completed instruction by May, 1998.

Test administration and observations. The pre-post tests were administered just before (within two days) and just after (within two days, and before the field test) the two week *FireWorks* curriculum was taught. For the two comparison groups that did not receive the *FireWorks* curriculum, teachers administered Form A (pretest) approximately two weeks before Form B (posttest). Form B was administered before the the students in the experimental group went on their field test.

Students in all classrooms were also asked to complete the Classroom Environment Scale during the two weeks time period the *FireWorks* curriculum was being taught. Because the semi-urban school had two teachers (one science and

one social studies) involved in the evaluation, each teaching the same group of students, the CES was only completed in the science classroom (all other classrooms were also science classrooms). It was not an option to request the students to complete the CES a second time. For the two comparison groups, the CES was administered at the same time as the paper-pencil tests.

In-class observations were conducted in all classrooms participating in the study using the In-class Observation Form (Appendix C). Observations were conducted in February before any *FireWorks* Curriculum was taught and in April and May, 1998, while the *FireWorks* curriculum was being taught. Each classroom was observed two times with the exception of one comparison school in the urban school district. The first observation in each pair was conducted to assist in observation design. The second observation was used to provide the data used in the analysis.

Field Test

Pilot Testing. In order to pilot the field test procedures, a group of 10 students, unexposed to the *FireWorks* curriculum, from an urban school in Missoula, Montana, responded to the behavioral tasks on March 13, 1998, at Pattee Canyon in the Lolo National Forest. The participants were divided into two "teams" of five students, with one adult accompanying each group, as would be the case in the actual testing.

Each of the two teams visited the six information stations in a different randomly assigned order. Each team received a different colored punch card, pink or yellow. At each station, the stationmaster explained the information station to the

team, using a description which was located on the stationmaster's copy of the tasks–for example, fire behavior, or safety of homes in the wildlands. Each member of the team was then asked to choose a different letter from the sequence A through E. The station master then called the student with "A" for his/her punch card, wrote the letter "A" in that information-station's square located on the punch card. The stationmaster then requested the student to do the task assigned to "A."

After the student responded, the stationmaster, using a hole punch, punched through the number of the information station if the student answer was correct, or on the corner opposite the number if answer was incorrect. This procedure continued until all students completed all the station. The students were thanked at each station but not told if their responses were correct in order to minimize students' sharing of information and possibly contaminating the test results. The escort then took the team to the next assigned station and the procedure described above was repeated. After all information stations were visited, the team returned to a central location to give their punch cards to the coordinator of the pilot study.

The results of each of the two "teams" were analyzed, and recommendations for changes were made as described in Appendix G (See Appendix G for Pilot items).

Field test with participants. Eleven classrooms received the *FireWorks* curriculum. Ten classrooms receiving the *FireWorks* curriculum and two non-treated classrooms participated in the outdoor structured field test in order to evaluate the *FireWorks* curriculum's effectiveness. Because the teacher did not

want to disrupt the students' class schedule, one urban classroom received the *FireWorks* curriculum but did not participate in the field test. The field tests were conducted on March 30 (1 school, rural), April 29 (2 schools, urban), May 7 (1 school, semi-urban) and May 8 (1 school, urban).

The location for the urban and semi-urban school field tests was Pattee Canyon in the Lolo National Forest. The site for the rural school field-test was located 7 miles northeast of Thompson Falls, Montana in the Lolo Forest. The two sites were chosen as stated above because they contained the physical environment required by the field-test and were a short distance from each school that participated. The two sites were judged to be generally similar in physical environment by Forest Service personnel.

The field test was conducted in the identical manner as the pilot field test. All classrooms received different colored punch cards as a simple way of separating data sets.

Three students from the University of Montana who received class credit for participation were stationmasters. Three employees of the Forest Service working at the Intermountain Fire Sciences Laboratory also acted as stationmasters.

Six Forest Service employees conducted "nature walks" because the field test was designed for classroom groups of about 30 and some schools had more than one classroom. One group participated in the field-test while the Forest Service employees conducted nature walks for the other. When the first group completed the field test, the groups switched. There were two nature walks in Thompson Falls, "big horn sheep" and "forest ecology." There were two nature walks in the Pattee

Canyon site, "weeds" and "leaving-no-trace camping." The team leaders were provided by the participating schools.

Order of station presentation was completely randomized to minimize order effects. For the larger schools an additional two stations were added. The stations were rest stops offering water and hard sugar candy. Each rest stop was randomized with the other stations. The rest stations were added to eliminate wait-time when group size exceeded 30 students.

Data entry

Following administration of the pre- and post-tests, the CES, classroom observations and completion of the field test, data was first coded into data sheets. All students, schools, and individual classrooms were assigned a numerical code and not identified by name, i.e., all responses were anonymous. In-class observation data was coded by classroom number only. All data were then entered into a mainframe data base for statistical analysis.

Results

Tests for homogeneity (means and variances) by school were conducted on the treatment and comparison group field test data, respectively. One treatment classroom, where 30% of the total group was special education students was eliminated ($n = 10$) because it differed statistically ($\alpha = .045$) from the other classrooms from that school. Treatment and control groups were then combined for the following analyses.

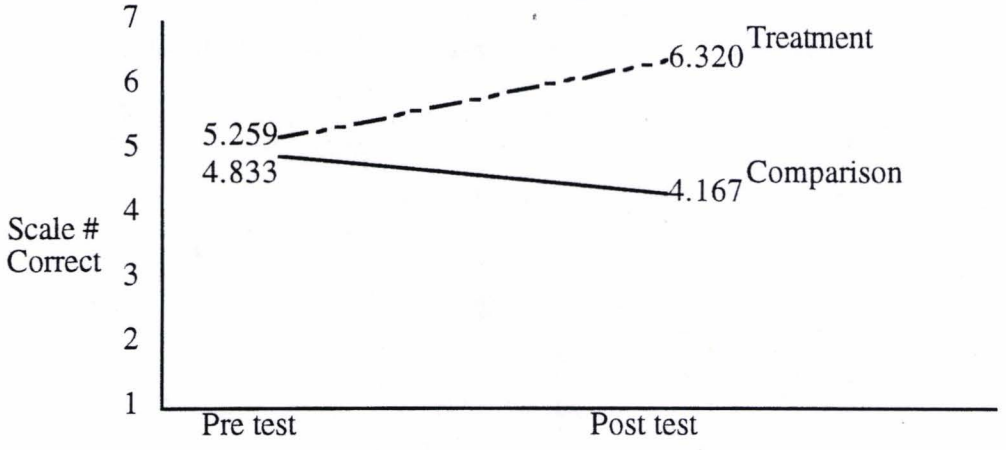
A one-way analysis of variance was conducted on the data and revealed highly significant results [$F(1, 239) = 13.65$, $p < .0005$]. Students participating in the

FireWorks curriculum performed better in a field demonstration of skills than did students who did not receive the *FireWorks* instruction. Mean numbers of correct responses were 3.883 (s = 1.257) for the treatment group as compared to 3.047 (s = 1.308) for the comparison group. This result was not only statistically significant, but, because the effect size was 0.65, of practical importance as well.

Assessment of the homogeneity of the field test items revealed only a moderate degree of internal consistency. In particular, responses to the items for Stations 2 and 6 and for Stations 3 and 5 were slightly negatively correlated. The overall alpha, using the Spearman-Brown correction for the five alternative items at each station was .65 (See Table 2, Appendix H)

A treatment-control by pre-post test analysis of variance was calculated on the cognitive test. (Figure 1). The results supported the prediction that the difference between students receiving *FireWorks* and those in the comparison group would be greater at post-test at pre-test [F (1,1) = 14.54, $p < .0005$]. It is interesting to note in Figure 1 that the mean score of the comparison group actually declined from pre-test to post-test (while those for the treatment group went up, as predicted). The difference between the treatment and comparison groups at pre-test was not significant.

Figure 1. Within subject effects of *FireWorks* pre-post tests.



A one-way analysis of variance by classroom was calculated on each of the nine Classroom Environmental Scale subscales. Results showed that classrooms differed significantly in perception of the classroom environment on all nine subscales. In particular, results indicated that there were significant differences between classrooms that received the *FireWorks* curriculum and those that did not in terms of the CES subscales of Teacher Involvement, Teacher Support, Task Orientation, Competition, Order and Organization, and Innovation as described below.

Analyses of CES Teacher Involvement subscale revealed significant differences between classrooms [$F(12, 278) = 10.30$, $p < .0005$]. However, the classrooms of the semi-urban school differed significantly from all others in terms of perceived Teacher Involvement [$F(5, 285) = 36.53$, $p < .0005$], and when those data were removed, significant differences between the treatment and comparison groups were revealed [$F(4, 211) = 14.95$, $p < .0005$]. As predicted students participating in the *FireWorks* curriculum were more engaged and attentive than were students in the comparison groups.

Analyses of the CES Teacher Support subscale revealed significant differences between classrooms [$F(12, 278) = 13.31$, $p < .0005$]. However, the classrooms of the semi-urban school differed significantly from all others in terms of perceived Teacher Support [$F(5, 285) = 26.88$, $p < .0005$], and when those data were removed, significant differences between the treatment and comparison groups were revealed [$F(4, 211) = 10.76$, $p < .0005$]. Teachers of the treatment group were

perceived by students as more trusting, interested in student ideas and more open to talk with students than the teachers of the comparison group.

Analyses of the CES Task Orientation subscale revealed significant differences between classrooms [$F(12, 278) = 9.57$, $p < .0005$]. However, the classrooms of the semi-urban school differed significantly from all others in terms of perceived Task Orientation [$F(5, 285) = 17.55$, $p < .0005$], and when those data were removed, significant differences between the treatment and comparison groups were revealed [$F(4, 211) = 4.32$, $p = .002$]. Teachers of the treatment group were perceived as placing more emphasis on completion of activities and staying on task than were the teachers of the comparison group.

Analyses of the CES Competition revealed significant differences between classrooms [$F(12, 278) = 10.30$, $p < .0005$]. However, the classrooms of the semi-urban school differed significantly from all others in terms of perceived Competition [$F(5, 285) = 22.01$, $p < .0005$], and when those data were removed, significant differences between the treatment and comparison groups were revealed [$F(4, 211) = 4.10$, $p = .003$]. Students in the treatment group perceived the classroom environment as more competitive and challenging in terms of receiving "good grades" than the students of the comparison group.

Analyses of the CES subscale of Order and Organization subscale revealed significant differences between classrooms [$F(12, 278) = 14.20$, $p < .0005$]. However, the classrooms of the semi-urban school differed significantly from all others in terms of the perception of Order and Organization [$F(5, 285) = 29.28$, $p < .0005$], and when those data were removed, significant differences between the treatment and

comparison groups were revealed [F (4, 211) = 10.38, p = .0005]. The teachers in the treatment group were perceived by students as placing more emphasis on appropriate student behavior as well as the organization of activities and assignments than the teachers of the comparison group.

Analyses of the CES Innovation subscale revealed significant differences between classrooms [F(12, 278) =11.58, p < .0005]. The semi-urban school data were analyzed, and finding no significant differences between other treatment classrooms, were included. Students in *FireWorks* classrooms described teachers as more likely to use new techniques, encourage creative thinking and allow student contribution in classroom activity than the teachers of the comparison classrooms.

Other Interesting trends. Classroom environment was perceived by students as the most supportive, promoting student involvement, and most innovative in urban school 1 (veteran male teacher). This school was also highest of all schools in four of the nine CES subscales: Involvement, Teacher Support, Order and Organization, and Innovation. Additionally, during the classroom observations this same school had the least number of students "not engaged", the least number of reminders about rule infractions, and most amount of time spent in instruction. Moreover, these classrooms appeared to be very orderly and organized during in-class observations compared to the other treatment classrooms in the urban and semi-urban schools, which appeared to be chaotic and disorganized.

The comparison group taught by the female veteran teacher in the urban school rated classroom environment much lower in Order and Organization as compared to the two treatment classes taught by the same teacher. It may be that the

structure of the *FireWorks* curriculum contributed to student perceptions of increased orderliness and organization.

A one-way analysis of variance was calculated on each of the six subdomains of the in-class observation data. Only one domain exhibited significant results. The data indicated that there were significant differences between classrooms that received the curriculum and those that did not in terms of Amount of Teacher Control Required [$F(1, 14) = 4.96$, $p = .043$]. Teachers of *FireWorks'* classrooms were less likely to be interrupted to reprimand students for infractions of rules than were teachers of comparison classrooms.

Discussion

This study demonstrated that *FireWorks,* a fire ecology program curriculum available as a traveling environmental educational trunk, was effective in promoting knowledge of fire ecology when administered to seventh-grade students in addition to their existing school curriculum. Analyses of treatment and comparison group scores for the both field-tests and the pre-post tests support the conclusion that the *FireWorks* instructional unit was effective in meeting its educational objectives.

While the results of the data analyses were statistically and practically significant, there were some design limitations. Because both comparison groups were from the same urban school district, comparison groups were not balanced across school types. Random assignment of classrooms would have provided a better comparison of teacher style, controlled for rural-urban differences, and elucidated classroom environment effects. And because volunteer schools each had

three classrooms participating, it would have been possible to randomly select a control group from each of the school's classrooms. However, since preparation of two different lectures would have been required by teachers when teaching both*FireWorks* to the treatment group and a different curriculum for the comparison group, random assignment was not an option that was acceptable to the teachers.

The number of students in the comparison group was much smaller than the treatment group (n= 261 and n= 52 respectively), and variability was generally greater in the comparison group than the treatment group, which may have contributed to Teacher Control as the only domain of the In-Class Observations reaching significance.

The results of the Classroom Environment Scale and the In-Class observation indicated that a structured curriculum such as *FireWorks* may be perceived by students as facilitating a better learning environment. In addition, it appears that the *FireWorks* curriculum may have contributed to student perceptions of increased orderliness and organization.

Treatment classrooms were perceived by students as having teachers who were more innovative, creative, and interested in student input than teachers in comparison classrooms. Moreover, students in the treatment classrooms were more interested, engaged and rated the classroom as a more helpful, orderly and friendly place to be than students in the comparison classrooms.

One possible shortcoming of the *FireWorks* curriculum is the recommended two weeks instruction time. The semi-urban school was able to

complete 72 percent of the activities with two teachers splitting up the activities, each teaching for two weeks (11 hours total for two classrooms). The rural school was able to complete about 66 percent of the activities, devoting about 10.5 hours to instruction of *FireWorks*. The two schools in the urban district each completed about 50 percent of the activities, one school devoting 9 hours and the other devoting about 5 hours to instruction of *FireWorks*. Although the curriculum was designed to be completed in eight hours of classroom time, most used at least 9 hours and did not finish in the two weeks. Lab clean-up time was not included in the eight hours suggested in the *FireWorks* curriculum manual, but several of the volunteer teachers suggested that it be factored in.

Implications of the Evaluation. Because the fire ecology instructional trunk evaluated in this study is effective in increasing knowledge of fire ecology, the results of this study have specific implications for educators and environmental officials who are planning ecology focused educational programs.

FireWorks was qualitatively evaluated by five participating science teachers who all said they would use the curriculum again. They expressed satisfaction with the materials, stating that "It was really fun doing the fire demonstrations." All of the teachers expressed enthusiasm for the field-based testing and requested the materials used in this evaluation be incorporated in the *FireWorks* trunk.

Further research, however, should attempt to gather empirical evidence that knowledge gains resulting from the *FireWorks* curriculum might influence a student's future behavior regarding efficient fire ecology practices. This information

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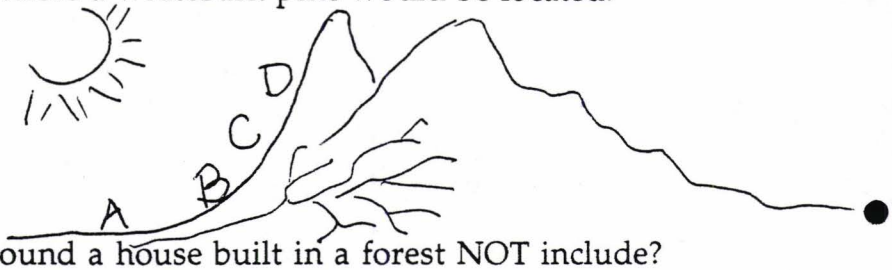
Appendix A

Pre- and Post-Tests

FORM A & FORM B

7. What kinds of fires were typical in ponderosa pine forests 100 years ago?
   a. surface fire every 5-30 years
   b. surface fire every 50-200 years
   c. crown fire every 50-200 years
   d. ground fire
   e. no fires at all

8. Choose from the sketch below where a whitebark pine would be located.
   a. Site A
   b. Site B
   c. Site C
   d. Site D
   e. Either Site A or B



9. What should the safety zone around a house built in a forest NOT include?
   a. green lawn
   b. ladder fuels
   c. flat site for house
   d. wide road

10. What kind of tree has 3-pronged bracts on cones?
   a. Engelmann spruce
   b. ponderosa pine
   c. western Larch
   d. Douglas-fir
   e. none of the above

11. Mushrooms at the base of a tree indicate:
   a. the tree may be as old as 200 years
   b. the trunk or roots are probably rotten
   c. the tree probably has dwarf mistletoe
   d. American martens probably live in the tree

12. Why does "stop, drop & roll" work to put out a fire?
   a. there is a lack of fuel
   b. there is lack of oxygen
   c. there is a lack of heat
   d. there is too much moisture

13. Which of the following would be likely to change a forest from ponderosa pine to Douglas-fir?
   a) removing ladder fuels
   b) 200 years without fire
   c) underburning every 20 years
   d) none of the above

KEY FORM A

1-A
2-A
3-C
4-C
5-D
6-A
7-A
8-D
9-B
10-D
11-B
12-B
13-B

Fireworks - Questions - FORM B

NAME_____ SCORE_____

Teacher_____

School _____

Choose the one (1) best answer for each question.

1. Which tree doesn't grow well in the shade?
   a. Douglas-fir
   b. lodgepole Pine
   c. subalpine Fir
   d. Engelmann Spruce
   e. none of the above

2. Compared to whitebark pine, the ponderosa pine generally grows at:
   a. higher elevations.
   b. lower elevations.
   c. the same elevations.
   d. none of the above

3. In what part of the forest do surface fires occur?
   a. treetop
   b. grass & shrubs
   c. roots
   d. soil

4. Which tree provides flammulated owls food?
   a. ponderosa pine
   b. lodgepole pine
   c. whitebark pine
   d. subalpine fir
   e. none of the above

5. Which trees need a bird for their cones to distribute seeds?
   a. ponderosa pine
   b. Douglas-fir
   c. lodgepole pine
   d. whitebark pine
   e. none of the above

6. If fire is kept out of a subalpine fir forest, which of these trees is likely to increase alot?
   a. Douglas fir
   b. western larch
   c. ponderosa pine
   d. black cottonwood
   e. none of the above

7. What kinds of fires were typical in lodgepole pine forests 100 years ago?
   a. surface fire every 5-30 years
   b. surface fire every 50-200 years
   c. crown fire every 50-200 years
   d. ground fire
   e. no fires at all

8. Choose from the sketch below where a lodgepole pine would be located.
   a. Site A
   b. Site B
   c. Site C
   d. Site D
   e. Either Site A or B

9. Which of the following is NOT included in the safety zone around a house built in a forest?
   a. trees or shrubs 5 m apart or more
   b. weeds cut, cleared out from lawn
   c. wood shake roof
   d. firewood stacked away from walls

10. What kind of tree has needles that fall off in the fall?
   a. Douglas-fir
   b. ponderosa pine
   c. Engelman spruce
   d. western Larch
   e. none of the above

11. If a tree has some branches growing in thick brooms of twigs,
   a. the tree may be as old as 200 years
   b. the trunk or roots are probably rotten
   c. the tree probably has dwarf mistletoe
   d Clark's nutcrackers probably live in the tree
   e. none of the above

12. If your clothes catch on fire, running is NOT a good idea because:
   a. running increases the supply of oxygen
   b. running increases the supply of fuel available
   c. running causes too much heat
   d. running dries your sweat

13. Which of the following would be likely to change a forest from subalpine fir to lodgepole pine?
   a. crown fire
   b. 200 years without fire
   c. cutting most of the trees, then planting lodgepole pine
   d. none of these

KEY FOR FORM B

1--B
2--B
3--B
4--A
5--D
6--E
7--C
8--C
9--C
10-D
11-C
12-A
13-C

Appendix B

CLASSROOM ENVIRONMENT SCALE

QUESTIONS

0. In the first few weeks the teacher explained the rules about what students could and could not do in this class.
1. The teacher will put up with a good deal.
2. Students can choose where they sit.
3. Students sometimes do extra work on their own in the class.
4. There are groups of students who don't get along in class.
5. This teacher does not trust students.
6. This class is more a social hour than a place to learn something.
7. Sometimes the class breaks up into groups to compete with each other.
8. Activities in this class are clearly and carefully planned.
9. Students aren't always sure if something is against the rules or not.
80. The teacher will kick a student out of class if he acts up.
81. Students do the same kind of homework almost every day.
82. Students really enjoy this class.
83. Some students in this class don't like each other.
84. Students have to watch what they say in this class.
85. The teacher sticks to classwork and doesn't get sidetracked.
86. Students usually pass even if they don't do much.
87. Students don't interrupt the teacher when he's talking.
88. The teacher is consistent in dealing with students who break the rules.
89. When the teacher makes a rule, he means it.
90. In this class, students are allowed to make up their own projects.

CLASSROOM ENVIRONMENT SCALE

FORM R

Edison J. Trickett & Rudolf H. Moos

Instructions

There are 90 statements in this booklet. They are statements about high school and junior high school classrooms. You are to decide which of these statements are true of your classroom and which are false.

Make all your marks on the separate answer sheet. If you think a statement is *True* or mostly *True* of your program, make an X in the box labeled T (true). If you think the statement is *False* or mostly *False* , make an X in the box labeled F (false).

Do not make any marks on this booklet.

Consulting Psychologists Press, Inc.
3803 E. Bayshore Road, Palo Alto, CA 94303

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99 98 97 12 11

1. Students p t of energy into what they do here.
2. Students in this class get to know each other really well.
3. This teacher spends very little time just talking with students.
4. Almost all class time is spent on the lesson for the day.
5. Students don't feel pressured to compete here.
6. This is a well-organized class.
7. There is a clear set of rules for students to follow.
8. There are very few rules to follow.
9. New ideas are always being tried out here.
10. Students daydream a lot in this class.
11. Students in this class aren't very interested in getting to know other students.
12. The teacher takes a personal interest in students.
13. Students are expected to stick to classwork in this class.
14. Students try hard to get the best grade.
15. Students are almost always quiet in this class.
16. Rules in this class seem to change a lot.
17. If a student breaks a rule in this class, he's sure to get in trouble.
18. What students do in class is very different on different days.
19. Students are often "clock-watching" in this class.
20. A lot of friendships have been made in this class.
21. The teacher is more like a friend than an authority.
22. We often spend more time discussing outside student activities than class-related material.
23. Some students always try to see who can answer questions first.
24. Students fool around a lot in this class.
25. The teacher explains what will happen if a student breaks a rule.
26. The teacher is not very strict.
27. New and different ways of teaching are not tried very often in this class.
28. Most students in this class really pay attention to what the teacher is saying.
29. It's easy to get a group together for a project.
30. The teacher goes out of his way to help students.
31. Getting a certain amount of classwork done is very important in this class.
32. Students don't compete with with each other here.
33. This class is often in an uproar.
34. The teacher explains what the rules are.
35. Students can get in trouble with the teacher for talking when they're not supposed to.
36. The teacher likes students to try unusual projects.
37. Very few students take part in class discussions or activities.
38. Students enjoy working together on projects in this class.
39. Sometimes the teacher embarrasses students for not knowing the right answer.
40. Students don't do much work in this class.
41. A student's grade is lowered if he gets homework in late.
42. The teacher hardly ever has to tell students to get back in their seats.
43. The teacher makes a point of sticking to the rules he's made.
44. Students don't always have to stick to the rules in this class.
45. Students have very little to say about how class time is spent.
46. A lot of students "doodle" or pass notes.
47. Students enjoy helping each other with homework.
48. This teacher "talks down" to students.
49. We usually do as much as we set out to do.
50. Grades are not very important in this class.
51. The teacher often has to tell students to calm down.
52. Whether or not students can get away with something depends on how the teacher is feeling that day.
53. Students get in trouble if they're not in their seats when the class is supposed to start.
54. The teacher thinks up unusual projects for students to do.
55. Students sometimes present something they've worked on to the class.
56. Students don't have much of a chance to get to know each other in this class.
57. If students want to talk about something this teacher will find time to do it.
58. If a student misses class for a couple of days, it takes some effort to catch up.
59. Students here don't care about what grades the other students are getting.
60. Assignments are usually clear so everyone knows what to do.
61. There are set ways of working on things.
62. It's easier to get in trouble here than in a lot of other classes.
63. Students are expected to follow set rules in doing their work.
64. A lot of students seem to be only half awake during this class.
65. It takes a long time to get to know everybody by his first name in this class.
66. This teacher wants to know what students themselves want to learn about.
67. This teacher often takes time out from the lesson plan to talk about other things.
68. Students have to work for a good grade in this class.
69. This class hardly ever starts on time.

Appendix C

In-Class Observation Form

The In-Class Observation Form

School_____ Period_____ **Class Time_____(Start)_____(End)[bell rings]**

Class Room
Teacher_____Date_____Number of Students_____

- **Domain #1: Involvement of students in class**
  The extent to which students are attentive/interested in class activities

Every 10 minutes # of students not engaged --are off task, talking, disruptive, etc.
Time Sampling 1= #
Time Sampling 2 = #
Time Sampling 3 = #
Time Sampling 4 = #
Time Sampling 5 = #
Total # students over 50 minutes_____

- **Domain #2-Involvement of teacher in instruction**

  The extent teacher is engaged in instruction:

[time actual instruction begins--do not include announcements, other information or business of classroom)
Mark time when teaching begins-then mark time when ends and continue to do so until class period is over]
Time Sampling 1= #
Time Sampling 2 = #
Time Sampling 3 = #
Time Sampling 4 = #
Time Sampling 5 = #
Total amt. time_____

- **Domain #3--Order and Organization**
  The emphasis on students behaving in an orderly and polite manner
  A. # times teacher reminds students about rules, stops instruction to correct. [count actual # of times any of behaviors occur]_____
  Total_____

  B. The # of times students are off task, disruptive, disorderly etc._____

Domain #4 Teacher Control:

How strict is the teacher in enforcing the rules-- 0=not at all, 1 =mildly; 2=moderately, 3=strongly, 4=severly or harshly
[rate the teacher on all the rule enforcement, then get a mean score by totaling and dividing by # of infractions observed.]

Domain #5-Student's opportunity to respond is high

How many times students asked questions in order to interact with teacher [count each question from teacher where s/he expects an answer--rhetorical does not count]_____

Total # students responding during class period_____{usually the same ones? or many different students?} count the number of students/and enthusiasm in responding [I know, I know, etc.]

Appendix D

Field-Test Stations With Items

Information Station #1. Fire Behavior

Location: Area with substantial duff, at least in pockets, substantial surface fuel, and some thickets of seedlings and saplings (ladder fuels). Fairly steep hillside visible.

	Student Tasks	Acceptable Answers
a	Show or describe to me the two parts of the Fire Triangle that are present here.	Fuel and oxygen. (Heat for ignition is missing.)
b	Show me three kinds of fuel that burn in a surface fire.	Litter, herbs, shrubs, tree seedlings and saplings (not crowns of large trees, not soil or duff).
c	Show and explain what fuels help a surface fire become a crown fire.	"Ladder fuels" are needed. This means there have to be places where fuel (usually tree foliage) is continuous from near the surface into the crowns of the large trees.
d	[Pointing to a hillside with dense forest cover] Tell me one way in which a surface fire would be likely to change if it reached that hillside over there.	On the hillside, fire will probably move faster & is more likely to crown.
e	Tell me one way you think a surface fire might benefit this forest.	Reduce risk of crown fire, increase forage, increase growth rate or improve health of large trees.

Information Station #2. Shrubs, Herbs, Pathogens

Location: a couple of shrubs obvious, also some grassy and herbaceous vegetation. Also, several mistletoe-infested trees should be visible.

	Student Tasks	Acceptable Answers
a	[Pointing to shrub or herb] Show or describe to me one part of this plant that is likely to survive most fires.	Underground parts or base of stems
b	[Pointing to witches'-broom from dwarf mistletoe] Tell me one way in which this mistletoe affects the tree (besides making it look funny).	Reduces tree growth and eventual death; forms potential habitat for small birds and their predators-- such as owls, hawks, and American martens.
c	Do you think mistletoe increases in this kind of forest without fire? Give a reason for your answer.	Douglas-fir mistletoe increases because it has lots of time to spread from tree to tree and because prevalence of its host tree increases.
d	[Pointing to a large pine] How could you tell if a flammulated owl or pileated woodpecker had used this tree for a nest?	It would have a large hole in it, high on the trunk.
e	Tell me one season of the year when elk would be more likely to use this habitat (if they live in the area and can get to it easily) than lodgepole pine or whitebark pine forest. Give one reason.	Winter or spring-- because this area has less snow and melts out earlier than lodgepole pine and whitebark pine forests.

Information Station #3: Tree Taxonomy & Adaptations Location: Near a mature ponderosa pine and a mature Douglas-fir		
Student Tasks		**Acceptable Answers**
a	Show me a ponderosa pine tree.	
b	Show me a Douglas-fir tree.	
c	Show me which kind of tree is more likely to survive a surface fire. Give one reason why this is so.	Ponderosa pine; thicker bark, thicker buds, higher and more open tree crown than that of Douglas-fir.
d	Show me which kind of tree was probably most numerous here 100 years ago. Give me one reason why.	Ponderosa pine; frequent surface fires used to eliminate most Douglas-firs. In the early 1900s, most large ponderosa pines were logged out.
e	There are no Engelmann spruce trees or cottonwoods here. Why don't they grow on this particular spot?	Site is too dry. Those species need more moisture.

Information Station #4. Fire History

Location: Near a fire scarred tree or stump.

	Student Tasks	Acceptable Answers
a	Show me some evidence that a fire burned here a long time ago.	Fire scarred tree. [If Thompson Falls students point to the blackened trees all around, remind them that you need evidence of fire *a long time ago*, not in the past few years.]
b	[If first student didn't point out the fire-scar, show it to students and say it's a scar made by fire in the past.] What kind of fire behavior is most likely to make a fire scar like this on a tree?	Surface fire, possibly combined with ground fire; not crown fire.
c	Show or explain to me how I could use this tree to figure out how many fires burned here and when they occurred.	Obtain a cross section (or possibly an increment core), count the fire scars, then count the growth rings between fire scars.
d	Tell me two ways in which this forest ecosystem looks different from the way it looked 100 years ago. NOTE: If students come up with answers about human development, ask them to try again, focusing on the forest ecosystem.	More young trees now-- especially more young Douglas-firs; less grass now; fewer large pines, especially if the area has obviously been logged; fewer shrubs; the shrubs present are larger, with more dead material in them.
e	Do you think fires have been less frequent here in the last 50 years than they were in the 1700s and 1800s? If so, how do you know? If not, how do you know?	Yes. We can tell from studying fire scars and from historic reports. The history of the past century tells that Native Americans were moved to reservations and that Euro-American settlers and their descendants have tried very hard to put out all fires.

Information Station #5. Homes and Fire

Location: At least one home in a forested environment.

	Student Tasks	Acceptable Answers
a	[Pointing to a nearby spot with dense trees and brush] If you were going to build a home on this spot, tell me two things you'd do to the site-- that is, the forest or the road access (NOT the house itself)-- to make it safer from wildland fire.	Well prepared= Within 10 m of the house (30 m on a hillside) there should be no ladder fuels, and trees and shrubs should be ≥ 5 m apart. If home is on a hillside, it should be set back from top of slope. Road should be wide enough for car and fire engine to pass.
b	[Pointing to a house in a wildland setting] Tell me one way in which this house (NOT the general area, but the house itself & stuff right next to it) is well prepared for wildland fire.	Well prepared= non-shake roof, wood stored away from home, weeds cleared from next to house, tree limbs cleared from roof and chimney area, no leaves on roof.
c	[Pointing to the same house] Tell me one way in which this house's protection from wildland fire could be improved-- without removing every tree from the site!	
d	If the nearest lodgepole pine forest is a mile away, should this homeowner worry about fires in that forest? Give one reason for your answer.	Yes, because fires can travel that far quite easily and quickly; and yes, because smoke from a fire that close would be very likely to surround this home.
e	Name two possible goals for management of forested land besides safety.	Wildlife habitat quality, revenue from logs, soil and watershed protection, scenic quality, other conservation goals.

Information Station #6. Lodgepole and Whitebark Pine

Location: At least some lodgepole pine cover should be visible. If this isn't possible, at least some high slopes with dense tree cover should be visible.

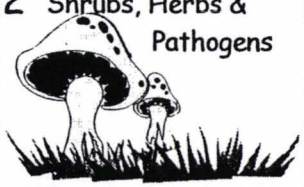
	Student Tasks	Acceptable Answers
a	Is there a place in view from here that would be a good location for lodgepole pine to grow? If so, why? If not, why not?	Yes-- high on a ridge or cold spot. No-- this area is too warm for lodgepole pine [First answer is OK for Thompson Falls site. Either answer is OK for the Pattee Canyon site, if the reason is given.]
b	Tell me one way in which the location for a whitebark pine forest would be different from the location of a lodgepole pine forest.	Higher elevation, colder, ridge top.
c	Tell me one way in which past fires in lodgepole pine forests usually differed from those in this location.	Less frequent, more severe, more likely to crown.
d	Here are cones from a pine tree growing on this site. This tree's seeds would probably not survive a crown fire because the cones open when the seeds are ripe, and the seeds drop to the ground. But other pines have ways to protect their seed from crown fire. Name one of these pines and explain how its seeds are protected.	Lodgepole pine protects some of its seeds by keeping them in the cone until a fire passes through and its heat opens the cones. Whitebark pine protects its seeds by having Clark's nutcrackers bury them underground, often in recently burned places.
e	Name one kind of plant, animal, or fungus that is more likely to kill a lot of trees in lodgepole or whitebark pine forests than here.	Mountain pine beetle, white pine blister rust.

Appendix E

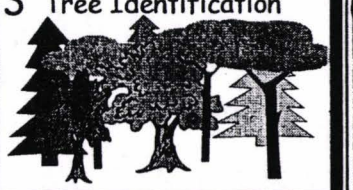
Punch Cards for Field Test

1 Fire Beh

2 Shrubs, Herbs & Pathogens



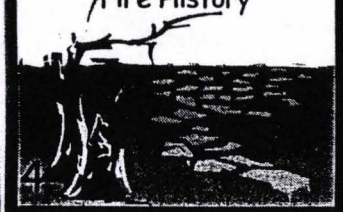
3 Tree Identification



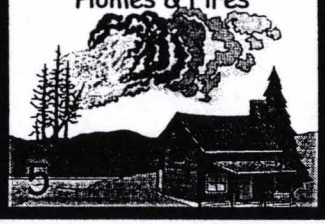
FireWorks for Grades 6-9

FIREWORKS

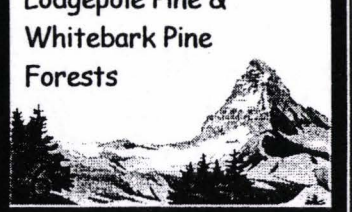
Fire History



Homes & Fires



Lodgepole Pine & Whitebark Pine Forests



Curriculum & Trunk Prepared by U.S.D.A Forest Service: Rocky Mountain Research Station

1 Fire Behavior

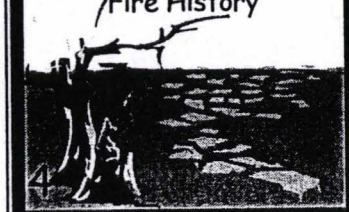
2 Shrubs, Herbs & Pathogens

3 Tre tification

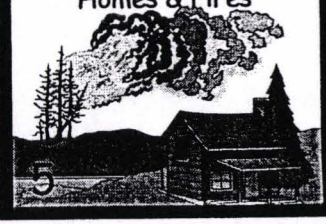
FireWorks for Grades 6-9

FIREWORKS

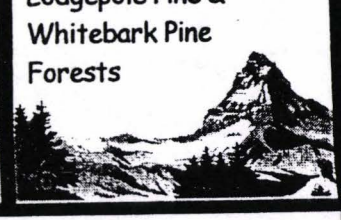
Fire History



Homes & Fires



Lodgepole Pine & Whitebark Pine Forests



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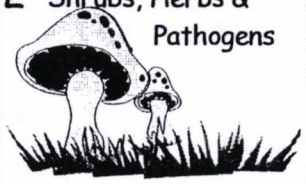
2 Shrubs, Herbs & Pathogens

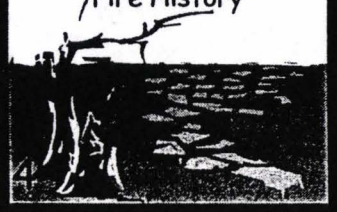


3 Tree Identification

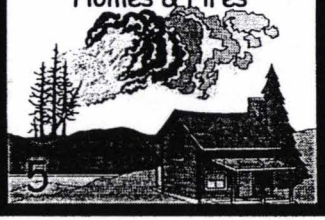
FireWorks for Grades 6-9

FIREWORKS

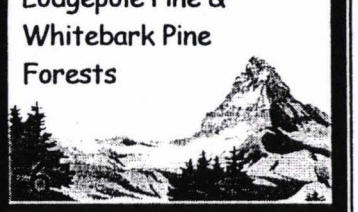
Fire History



Homes & Fires

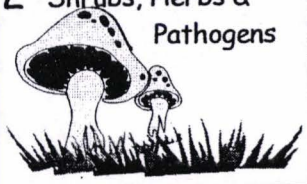


Lodgepole Pine & Whitebark Pine Forests



1 Fire Behavior

2 Shrubs, Herbs & Pathogens

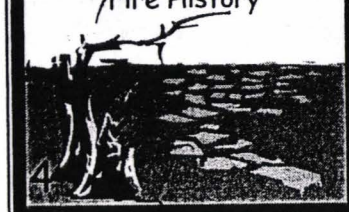


3 Tree Identification

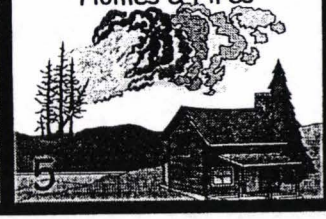
FireWorks for Grades 6-9

FIREWORKS

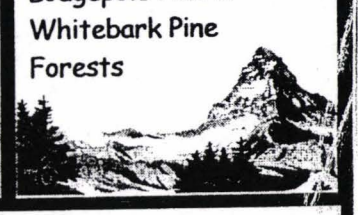
Fire History



Homes & Fires



Lodgepole Pine & Whitebark Pine Forests



Appendix F

Activity Check List

Volunteer Teachers Completed Checklists

FireWorks for Grades 6-9

Activity checklist

Topic	Activity	Title	Please check if you used activity	Approx. Classroom time
I		**Visiting Wildland Fire**		min.
II		**How Does Fire Work?**	Not applicable	
	1	Meeting the Fire Triangle		min.
	2*	Testing the Fire Triangle		min.
	3*	The Fire Triangle in Wildlands		min.
	4	People in Fire's Homeland		min.
III		**Neighborhood Trees**	Not applicable	
	1	Tree Portrait		min.
	2	Mystery Trees		min.
IV		**Tough Trees**	Not applicable	
	1*	Will It Burn?		min.
	2	Tree Skin		min.
	3	Recipe for a Lodgepole Pine Forest		min.
	4*	Tinker Tree Derby		min.
	Optional Integration & Closure: *Designer Trees*			min.
V		**Tree Stories**	Not applicable	
	1	Tree History		min.
	2	Forest Stories: Repeating Themselves?		min.
VI		**Enlarging the Picture**	Not applicable	
	1	Always Changing		min.
	2	Puzzling It Out		min.
VII		**Dealing with Fire**	Not applicable	
	1	You Decide!		min.
	2	Revisiting Wildland Fire		min.

*Activities that use fire

FireWorks for Grades 6-9

Activity checklist

Topic	Activity	Title	Please check if you used activity	Approx. Classroom time
I		**Visiting Wildland Fire**	✓	40 min.
II		**How Does Fire Work?**	Not applicable	
	1	Meeting the Fire Triangle	✓	20 min.
	2*	Testing the Fire Triangle	✓	60 min.
	3*	The Fire Triangle in Wildlands	✓	60 min.
	4	People in Fire's Homeland		min.
III		**Neighborhood Trees**	Not applicable	
	1	Tree Portrait	✓	25 min.
	2	Mystery Trees	✓	75 min.
IV		**Tough Trees**	Not applicable	
	1*	Will It Burn?	✓	45 min.
	2	Tree Skin		mi
	3	Recipe for a Lodgepole Pine Forest	✓	30 min.
	4*	Tinker Tree Derby	✓	50 min.
	Optional Integration & Closure: *Designer Trees*			min.
V		**Tree Stories**	Not applicable	
	1	Tree History	✓	30 min.
	2	Forest Stories: Repeating Themselves?	✓	20 min.
VI		**Enlarging the Picture**	Not applicable	
	1	Always Changing		min.
	2	Puzzling It Out	✓	40 min.
VII		**Dealing with Fire**	Not applicable	
	1	You Decide!		min.
	2	Revisiting Wildland Fire		min.

*Activities that use fire

This is as close as I can recall. I know each class spent about 9-10 hrs on the course. I ran out of time so I couldn't do every section. Clean-up needs to be factored into the time on the different activities.

Kelly

FireWorks for Grades 6-9

Activity checklist

Topic	Activity	Title	Please check if you used activity	Approx. Classroom time
I		**Visiting Wildland Fire**	✓	40 min.
II		**How Does Fire Work?**	Not applicable	
	1	Meeting the Fire Triangle	✓	45 min.
	2*	Testing the Fire Triangle	✓	45 min.
	3*	The Fire Triangle in Wildlands	✓	45 min.
	4	People in Fire's Homeland	✓	20 min.
III		**Neighborhood Trees**	Not applicable	
	1	Tree Portrait		min.
	2	Mystery Trees		min.
IV		**Tough Trees**	Not applicable	
	1*	Will It Burn?	✓	45 min.
	2	Tree Skin		min.
	3	Recipe for a Lodgepole Pine Forest	✓	40 min.
	4*	Tinker Tree Derby		min.
	Optional Integration & Closure: *Designer Trees*			min.
V		**Tree Stories**	Not applicable	
	1	Tree History		min.
	2	Forest Stories: Repeating Themselves?		min.
VI		**Enlarging the Picture**	Not applicable	
	1	Always Changing		min.
	2	Puzzling It Out		min.
VII		**Dealing with Fire**	Not applicable	
	1	You Decide!		min.
	2	Revisiting Wildland Fire		min.

*Activities that use fire

FireWorks for Grades 6-9

Activity checklist

Topic	Activity	Title	Please check if you used activity	Approx. Classroom time
I		**Visiting Wildland Fire**		min.
II		**How Does Fire Work?**	Not applicable	
	1	Meeting the Fire Triangle		min.
	2*	Testing the Fire Triangle		min.
	3*	The Fire Triangle in Wildlands		min.
	4	People in Fire's Homeland		min.
III		**Neighborhood Trees**	Not applicable	
	1	Tree Portrait	✓	20 min.
	2	Mystery Trees	✓	20 min.
IV		**Tough Trees**	Not applicable	
	1*	Will It Burn?		min.
	2	Tree Skin		mi
	3	Recipe for a Lodgepole Pine Forest		min.
	4*	Tinker Tree Derby		min.
	Optional Integration & Closure: *Designer Trees*			min.
V		**Tree Stories**	Not applicable	
	1	Tree History	✓	50 min.
	2	Forest Stories: Repeating Themselves?	✓	50 min.
VI		**Enlarging the Picture**	Not applicable	
	1	Always Changing		min.
	2	Puzzling It Out	✓	20 min.
VII		**Dealing with Fire**	Not applicable	
	1	You Decide!	✓	30 min.
	2	Revisiting Wildland Fire		min.

*Activities that use fire

2

FireWorks for Grades 6-9

Activity checklist

Topic	Activity	Title	Please check if you used activity	Approx. Classroom time
I		**Visiting Wildland Fire**		min.
II		**How Does Fire Work?**	Not applicable	
	1	Meeting the Fire Triangle } Did Together	✓	55 min.
	2*	Testing the Fire Triangle }	✓	✓ min.
	3*	The Fire Triangle in Wildlands	✓	55 min.
	4	People in Fire's Homeland	✓	30 min.
III		**Neighborhood Trees**	Not applicable	
	1	Tree Portrait		min.
	2	Mystery Trees modified to fit my needs (3rd day - Test.)	✓	2 classes 80 min.
IV		**Tough Trees**	Not applicable	
	1*	Will It Burn?	✓	50 min.
	2	Tree Skin	✓	2 - 50 min classes min. 10
	3	Recipe for a Lodgepole Pine Forest		min.
	4*	Tinker Tree Derby	✓	50 min.
	Optional Integration & Closure: *Designer Trees*			min.
V		**Tree Stories**	Not applicable	
	1	Tree History	✓	50 min.
	2	Forest Stories: Repeating Themselves?		min.
VI		**Enlarging the Picture**	Not applicable	
	1	Always Changing		min.
	2	Puzzling It Out		min.
VII		**Dealing with Fire**	Not applicable	
	1	You Decide!		min.
	2	Revisiting Wildland Fire		min.

*Activities that use fire

9 hrs

FireWorks for Grades 6-9

Activity checklist

Topic	Activity	Title	Please check if you used activity	Approx. Classroom time
I		**Visiting Wildland Fire**	✓	20 min.
II		**How Does Fire Work?**	Not applicable	
	1	Meeting the Fire Triangle	✓	30 min.
	2*	Testing the Fire Triangle Exp. #1 only	✓	15 min.
	3*	The Fire Triangle in Wildlands no smoke	✓	20-30 min.
	4	People in Fire's Homeland	✓	15 min.
III		**Neighborhood Trees**	Not applicable	
	1	Tree Portrait	✓	25 min.
	2	Mystery Trees part 2 40min.	✓ part 1 only	30 min.
IV		**Tough Trees**	Not applicable	
	1*	Will It Burn? p1 only	35	35 min.
	2	~~Tree Skin~~		mi
	3	Recipe for a Lodgepole Pine Forest	✓	20 min.
	4*	~~Tinker Tree Derby~~		min.
		Optional Integration & Closure: *Designer Trees*		min.
V		**Tree Stories**	Not applicable	
	1	Tree History p6 only	30	min.
	2	Forest Stories: Repeating Themselves?		min.
VI		**Enlarging the Picture**	Not applicable	
	1	Always Changing		min.
	2	Puzzling It Out	P1 only	20 min.
VII		**Dealing with Fire**	Not applicable	
	1	~~You Decide!~~		min.
	2	~~Revisiting Wildland Fire~~		min.

*Activities that use fire

lines 250

p6: Steve Ellingson & Kris Headlee did the slope burning, Fire △ Twic

p5: Jennifer Elins also cut above info inch

Recommended Changes to Piloted Items in Field Test

Station 1 (Fire Behavior): Item A was changed to "show or describe to me the two parts of the Fire Triangle that are present here." Original item A was moved to Item B position, and Item B moved to Item C position. The original Item C was deleted ("What weather conditions would be needed for a crown fire to occur here?").

Station 4 (Fire History): Item A had a wording change from "...in the last few centuries." to "...a long time ago." The position Item B and Item C were exchanged, with instructions "to point out a fire-scar to students if the student who was to answer Item A did not point it out" added to the new Item B.

Station 5 (Homes and Fire): Item B had additional instructions for the station master were added, "Pointing to a house in a wildland setting." Item C wording was simplified from "Which house here do you think is better prepared for a wildland fire? Explain your reasoning, using a different basis than the one just given" to "Tell me one way in which this house's protection from wildland fire could be improved--without removing every tree from the site!"

No changes were made to any items for Station 2, Station 3, and Station 6.

Information Station #1. Fire Behavior

Location: Area with substantial duff, at least in pockets, substantial surface fuel, and at least some thickets of seedlings and saplings (ladder fuels). Fairly steep hillside visible.

	Student Tasks	Acceptable Answers
a	Show me three kinds of fuel that burn in a surface fire.	Litter, herbs, shrubs, tree seedlings and saplings
b	Show and explain what fuels help a surface fire become a crown fire.	"Ladder fuels" are needed. This means there have to be places where fuel (usually tree foliage) is continuous from near the surface into the crowns of the large trees.
c	What weather conditions would be needed for a crown fire to occur here?	Very dry conditions and very high winds
d	Tell me one way in which a surface fire would be likely to change when it reaches that hillside over there.	Fire will probably move faster and be more likely to crown on the hillside.
e	Tell me one way you think a surface fire could benefit this forest.	Reduce risk of crown fire, increase forage, increase growth rate or improve health of large trees.

Information Station ~~#4~~ 2 Shrubs, Herbs, Pathogens

Location: a couple of shrubs obvious, also some grassy and herbaceous vegetation. Also, several mistletoe-infested trees should be visible.

	Student Tasks	Acceptable Answers
a	[Pointing to shrub or herb] Show or describe to me one part of this plant that is likely to survive most fires.	Underground parts or base of stems.
b	[Pointing to witches'-broom from dwarf mistletoe] Tell me one way in which this mistletoe affects the tree (besides making it look funny).	Reduced tree growth and eventual death; forms potential habitat for small birds and their predators-- such as owls, hawks, and American martens.
c	Do you think mistletoe increases in this kind of forest without fire? Give a reason for your answer.	Douglas-fir mistletoe increases because it has lots of time to spread from tree to tree and because prevalence of its host tree increases.
d	[Pointing to a large pine] How ~~would this tree look different~~ could you tell if a flammulated owl or pileated woodpecker used it for a nest?	It would have a large hole in it, high on the trunk.
e	Tell me one season of the year when elk would be more likely to use this habitat (if they live in the area and can get to this forest) than the other forests we have studied. Explain why.	Winter, spring-- because this area has less snow and melts out earlier than lodgepole pine and whitebark pine forests.

Information Station #3 Tree Taxonomy & Adaptations Location: near a mature ponderosa pine and a mature Douglas-fir.		
	Student Tasks	**Acceptable Answers**
a	Show me a ponderosa pine tree.	
b	Show me a Douglas-fir tree.	
c	Show me which kind of tree is more likely to survive a surface fire. Give one reason why this is so.	Ponderosa pine; thicker bark, thicker buds, higher and more open crown than those of Douglas-fir.
d	Show me which kind of tree was probably most numerous here 100 years ago. Give me one reason why.	Ponderosa pine; frequent surface fires used to eliminate most Douglas-firs. In the early 1900s, most large ponderosa pines were logged out.
e	There are no Engelmann spruces, or cottonwoods, ~~or western larches~~ here. Why don't they grow at this particular spot?	Site is too dry. Those species need more moisture.

Information Station #4 Fire History

Location: Near a fire scarred tree or stump.

	Student Tasks	Acceptable Answers
a	Show me some evidence that a fire has burned here in the last few centuries.	Fire-scarred tree.
b	Show or explain to me how I could use this tree to figure out how many fires have burned here and when they occurred.	Obtain a cross section (or possibly an increment core), then count the growth rings between fire scars.
c	What kind of fire behavior is most likely to make scars like these on a tree?	Surface fire, possibly combined with ground fire; not crown fire
d	Tell me two ways in which this forest ecosystem looks different from the way it did 100 years ago. NOTE: If students come up with answers about human development, ask them to try again, focusing on the forest ecosystem.	More young trees now-- especially more young Douglas-firs, less grass, fewer large pines especially if the area has obviously been logged, fewer shrubs, larger shrubs with a lot of dead material in them.
e	Do you think fires have been less frequent here in the last 50 years than they were in the 1700s and 1800s? If so, how do you know? If not, how do you know?	Yes. We can tell from studying fire scars. We can also learn from historic reports. The history of the past century tells us that people have tried very hard to put out all fires during that time.

Information Station #5. Homes and Fire

Location: At least one home in a forested environment.

	Student Tasks	Acceptable Answers
a	[Pointing to a nearby spot with dense trees and brush] If you were going to build a home on this spot, tell me two things you'd do to the site-- that is, the forest ~~within about 10 m of the house or the road access~~ (NOT the house itself)-- to make it safer from wildland fire.	Well prepared= Within 10 m of the house (30 m on a hillside) there should be no ladder fuels, and trees and shrubs should be $\geq$ 5 m apart. If home is on a hillside, it should be set back from top of slope. Road should be wide enough for car and fire engine to pass.
b	Which house here (NOT the general area around the house, but the house itself & stuff right next to it) do you think is better prepared for a wildland fire? Explain your reasoning.	Well prepared= non-shake roof, wood stored away from home, weeds cleared from next to house, tree limbs cleared from roof and chimney area, no leaves on roof.
c	Which house here (NOT the general area around the house, but the house itself & stuff right next to it)do you think is better prepared for a wildland fire? Explain your reasoning, using a different basis than the one just given.	
d	If the nearest lodgepole pine forest is a mile away, should this homeowner worry about fires in that forest? Give one reason for your answer.	Yes, because fires can travel that far quite easily and quickly; and yes, because smoke from a fire that close would be very likely to surround this home.
e	Name two possible goals for forested land besides safety.	Wildlife habitat quality, revenue from logs, soil protection, scenic quality, other conservation goals.

Information Station #6. Lodgepole and whitebark pine

Location: At least some lodgepole pine cover should be visible. If this isn't possible, at least some high slopes with dense tree cover should be visible.

	Student Tasks	Acceptable Answers
a	Is there a place in view from here that would be a good location for lodgepole pine? If so, why? If not, why not?	Yes-- high on a ridge or cold spot. No-- this area is too warm for lodgepole pine.
b	Tell me one way in which the location for a whitebark pine forest would be different from the location of a lodgepole pine forest.	higher elevation, colder, ridge top
c	Tell me one way in which past fires in lodgepole pine forests usually differed from those in this location.	Less frequent, more severe, more likely to crown
d	Here are cones from a pine tree growing on this site. This tree's seeds would probably not survive crown fire because the cones open when the seeds are ripe, and the seeds drop to the ground. But other pines have ways to protect their seed from crown fire. Name one of these pines and explain how its seeds are protected.	Lodgepole pine protects some of its seeds by keeping them in the cone until a fire passes through and its heat opens the cones. Whitebark pine protects its seeds by having Clark's nutcrackers bury them underground, often in recently burned places.
e	Name one kind of plant, animal, or fungus that is more likely to kill a lot of trees in lodgepole or whitebark pine forests than here.	Mountain pine beetle, white pine blister rust

Appendix H

Inter-Item Correlations

Field-Test Stations Student Questions

Table 2.

	Station 1	Station 2	Station 3	Station 4	Station 5
Station 2	0.039				
Station 3	0.258	0.026			
Station 4	0.104	0.108	0.026		
Station 5	0.062	0.044	-0.052	0.056	
Station 6	0.128	-0.070	0.106	0.018	0.048

Appendix I

FireWorks Curriculum Used in *FireWorks* Evaluation

FireWorks

Curriculum
Draft 2-14-98

Curriculum and Trunk prepared by U.S.D.A. Forest Service:
Rocky Mountain Research Station
Northern Region
Bitterroot Ecosystem Management Research Project

Jane Kapler Smith and Nancy McMurray
Intermountain Fire Sciences Laboratory
P.O. Box 8089, Missoula, MT 59807
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***FireWorks*: Why??** Change is an integral part of a healthy, enduring forest. *FireWorks* provides students with interactive, hands-on materials to study the forces that cause change in forests. *FireWorks* provides teachers with a complete curriculum for each of two age levels, Grades 1-5 and Grades 6-9. Content of the curriculum focuses on fire, addressing five themes:

- wildland fire behavior
- characteristics that enable plant and animal populations to survive fire
- the "fire history" of forests
- change in forest communities over time
- people's influences on forests and wildland fire

The science of wildland fire provides a context for learning about properties of matter, ecosystem fluctuations and cycles, habitat and survival, and human effects on ecosystems. These concepts are considered benchmarks for science literacy (American Association for the Advancement of Science 1993). Students using *FireWorks* gather information, analyze and interpret it, and communicate their discoveries. These are learning styles that enhance understanding, cognitive skills, and social skills (National Research Council 1996).

Students learn best about ecology when it is close to home-- when they can study the plants, animals, and fire regimes typical of local ecosystems. *FireWorks* uses hands-on materials (listed in Appendix 1) to describe fire ecology in forests of the northern Rocky Mountains and the Intermountain area. It focuses especially on the relationship between fire and the inhabitants of three kinds of forest: ponderosa pine/Douglas-fir, lodgepole pine/subalpine fir, and whitebark pine/subalpine fir.

Excellent curricula are available for studying fire ecology[1], and *FireWorks* draws upon many of them. To investigate some of the most interesting aspects of this subject, however, some special materials are necessary. Fire-scarred tree cookies are an example. Collections of photos and essays about local plants, animals, and fungi is another. Hoping to share the excitement of learning firsthand about fire, we have developed this set of materials for use in the classroom and laboratory environments. For learning about the woods, however, there is nothing as good as being out there! We encourage you to take your students on a field trip after studying *FireWorks*. Many of the *Extension and Enrichment* activities included in *FireWorks* describe field activities.

Educational objectives of *FireWorks*

1. To increase student understanding
   - of the physical science of combustion, especially in wildland fuels
   - that a forest has many kinds of plants and animals, which change over time and influence one another

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[1]Appendix 2 lists other curricula for teaching about wildland fire.

- that fire is an important natural process in many forest ecosystems
- that native plants and animals have ways to survive fire or reproduce after fire, or both
- that people influence fire-dependent wildlands in the areas where they live
- that people respond in different ways to fire-related questions

2. To increase student skills in
   - making observations
   - classifying information
   - measuring, counting, and computing
   - stating and testing hypotheses
   - describing observations, both qualitatively and quantitatively
   - explaining reasoning
   - identifying and expressing responses to fire-related questions
   - working in teams to solve problems
   - critical listening and reading

Meeting these educational objectives contributes to implementation of the recommendation from the Federal Wildland Fire Management Policy & Program Review (U.S.D.I. and U.S.D.A. 1995) to "transmit a clear message about the important role of fire as a natural process" (p. 12).

Fire Ecology: Background. Many authors have written eloquently, with beautiful graphics, about fire ecology. Much of this work is included in the *FireWorks Library* and the *Teacher Box*. For **General background** on fire ecology, look especially at the following:

- "Teacher Background Information" in the *Fire Ecology Resource Management Education Unit* (in the *Teacher Box*) provides a clear summary of principles of fire ecology that apply throughout the United States. This curriculum, produced by the U.S. Department of the Interior, also contains a concise, 3-page folder of "Fire Facts - Student Background Information." Other resources in the *Fire Ecology Resource Management Education Unit*: an excellent "Glossary of Fire Terms" and a list of "Fire References."

- Two *National Geographic* articles on fire in the *FireWorks Library*:
  - "The Great Yellowstone Fires" by David Jeffery, pages 252 to 273 in the February 1989 issue, Vol. 175 (2) describes the 1988 fire in Yellowstone National Park, the fire suppression effort there, and the fires' effects on the ecosystem.
  - "The Essential Element of Fire" by Michael Parfit, pages 116 through 139 in the September 1996 issue, Vol. 190 (3) describes the ecology of dry North American forests, including the widespread fire-dependent ponderosa pine forests of the western United States.

- *Fire in Florida's Ecosystems* Educator's Guide (in the *FireWorks Library*) describes fire ecology in a very different region of the U.S. (pp. 4-13). You may find that the fire ecology of Florida is, in many ways, very similar to that of Montana and Idaho. Student background information on fire in Florida is on pp. 14-16.

- *Fire - a Force of Nature* (in the *FireWorks Library*) contains beautiful photographs and clear text about fire ecology in North America. This book devotes special sections to fire in the Everglades, the giant sequoia groves of California, the area in and around Yellowstone National Park, southern California, and Alaska.

Many resources in the *FireWorks Library* and *Teacher Box* focus on particular topics in fire ecology. We list specific **Resources for Background Information** at the start of each investigation in *FireWorks*.

How is *FireWorks* organized?

Both *FireWorks* curricula (for Grades 1-5 and Grades 6-9) are divided into major **topics**. Then each **topic** is investigated using one or more **activities**.

A brief description of the concepts in each **topic** is followed by a list of
- resources for background information
- subjects covered in the activities
- educational objectives (skills and content)
- list of the activities

Each **activity** is organized as follows:
- "What's the Point?" summary of concepts
- "You will need:" approx. classroom time, materials and supplies
- "Procedures" Many activities are written for 4 work stations and student teams.
- "Closure"

Opportunities for *integration* with *details from your regular curriculum* are described within the instructions for various activities, set apart in frames like this.

We also present **SPARKS OF INFO,** information that you may find useful but is probably not essential for teaching *FireWorks*.

At the end of the activities for each topic, a section entitled **Enrichment and Extension** describes additional activities relating to the topic.

Safety is a Big Deal.

In *FireWorks*, you will do demonstrations and experiments that use fire. This kind of investigation brings responsibilities with it--for teachers, administrators, and students. Here are some suggestions for helping things run smoothly and safely:

- Inform your principal, local fire protection unit, and maintenance staff about activities in which you will use fire.

- For experiments using matches and fire, choose your work space carefully, especially if you will not be using a laboratory. Schools are equipped with sensitive smoke alarms, which are connected in a direct line to fire stations. Even if you are working in a laboratory, you may set off the smoke alarm, so check it out ahead of time. Fire protection staff must respond to every alarm, even if you tell them it's "only" smoke from an experiment. If you are working outdoors, watch carefully to prevent smoldering material from igniting schoolyard vegetation.
- Keep the *FireWorks* spray bottles filled with water. Put them in locations where you and the students can find and use them quickly. Use them especially to extinguish smoldering material at the end of each experiment; this will prevent trash-can fires.
- Keep the *FireWorks* fire extinguisher--and any other extinguishers in your classroom--ready for use. Know how to use them.
- Follow the instructions for personal safety on the *FireWorks Safety* poster (in the trunk).
- If you or any of your students have asthma or respiratory problems, consider using a dust mask when working with fire.

Fire is both powerful and dangerous. Learning more about it should not make us respect it less. Careless use of fire, including unsupervised use of fire by children, can cause terrible injuries and property damage. Please encourage your students to use what they learn in *FireWorks* to increase their safety, both at home and in wildlands.

Evaluation. Appendix 3 offers suggestions for student evaluation and an opportunity for you to critique *FireWorks*. Your comments are very important for this pilot stage. We have done the best we could to get the materials and curriculum ready for your class. Your comments will help us improve it.

Citations

American Association for the Advancement of Science. 1993. Benchmarks for science literacy. New York: Oxford University Press. 418 p.

National Research Council. 1996. National science education standards. Washington, DC: National Academy Press. 262 p.

U.S. Department of Interior and U.S. Department of Agriculture. 1995. Federal wildland fire management policy & program review, final report (December 18, 1995). Boise, ID: National Interagency Fire Center, Bureau of Land Management, Office of Fire and Aviation. 45 p.

FireWorks
Curriculum for Grades 6-9

To the Teacher: Thank you very much! We hope *FireWorks* serves you well in teaching. We will be glad to hear from you about ways to improve it.

As you survey the whole curriculum before launching it in your classroom, we suggest that you think about how to handle the logistics of sharing materials and pacing student work. Some *FireWorks* activities are designed as demonstrations, some as class discussions. Many are designed as student laboratories-- usually for four to eight teams of students. Toward the end of the curriculum, activities rely more on student work-- individually and in groups-- to integrate information. While doing activities from the early part of the curriculum, you may want to assign individual work from later lessons as homework so students will be prepared for the integrative activities when you get to them.

We deeply appreciate the work that you do with your students and the rapid, dramatic changes they go through in grades 6-9. We know that different *FireWorks* activities and different learning styles will appeal to different classes. To provide some flexibility in teaching and learning styles, we refer often in the curriculum to "alternative" and "optional" activities that may work better. Please be patient with the cross-references; ignore them if you wish.

Thank you for bringing fire's story to your students. We hope you enjoy using *FireWorks*!

Topics and Activities
FireWorks for Grades 6-9

Total classroom time: 8-9 hours

Topic	Activity	Title	Approx. Time(min)	page
I		**Visiting Wildland Fire**	30	M-3
II		**How Does Fire Work?**	**(110 total)**	M-8
	1	Meeting the Fire Triangle	20	M-9
	2*	Testing the Fire Triangle	30	M-13
	3*	The Fire Triangle in Wildlands	40	M-15
	4	People in Fire's Homeland	20	M-19
III		**Neighborhood Trees**	**(65 total)**	M-22
	1	Tree Portrait	15	M-23
	2	Mystery Trees	50	M-25
IV		**Tough Trees**	**(115-155)**	M-30
	1*	Will It Burn?	30	M-32
	2	Tree Skin	20	M-35
	3	Recipe for a Lodgepole Pine Forest	20	M-38
	4*	Tinker Tree Derby	45	M-40
	Optional Integration & Closure: *Designer Trees*		40 opt.	M-43
V		**Tree Stories**	**(40 total)**	M-47
	1	Tree History	20	M-48
	2	Forest Stories: Repeating Themselves?	20	M-50
VI		**Enlarging the Picture**	**(60 total)**	M-53
	1	Always Changing	45	M-55
	2	Puzzling It Out	15	M-57
VII		**Dealing with Fire**	**(125 total)**	M-63
	1	You Decide!	95	M-65
	2	Revisiting Wildland Fire	30	M-68

*Activities that use fire

Topic I. *Visiting Wildland Fire*, a slide show for students in grades 6-9

Basic Concept: Fire is very dramatic and evokes strong feelings in all of us. This slide show (which we plan to add sounds to when time is available) gives students an opportunity to reflect on their thoughts and feelings about wildland fire. Students respond to photos of fire and its effects in each of three forest types: ponderosa pine/Douglas-fir, lodgepole pine/subalpine fir, and whitebark pine/subalpine fir. These three forest communities, selected from a wide variety of forest types in the northern Rocky Mountains and Intermountain area, illustrate the variation in fire behavior, ecology, and succession that characterizes our forests. The curriculum focuses on them frequently.

Re-use this slide show at the end of your study of *FireWorks* (Activity VII-2), so students can reflect on their thoughts and feelings in the light of new experience.

Background: See **Fire Ecology Background**, pp. 6-7 in the Introduction.

Subjects:
Language
Art
Social Science
Ecology

Objectives:
1. To increase students' ability to
   - identify and describe their feelings
   - understand the feelings of others

2. To increase student understanding
   - that wildland fire behavior and effects are complicated and variable

You will need about 30 minutes of classroom time plus the following:

In this trunk	***You must supply***
Visiting Wildland Fire slide carousel	slide projector & screen
	flipchart paper & markers
	paper and art supplies

Procedure:
1. Explain that the class will be studying wildland fire in the coming week or two. Explain: Fire is a natural process in most wildlands of North America, and fires have occurred in the forests of the western states for tens of thousands of years.
2. Explain: In this slide show, students will see photos of fire and of burned areas in forests of the northern Rocky Mountains and the Intermountain area. They will see fire in three different kinds of forest, which they will study more thoroughly with later activities. (When the sound track becomes available: They will also hear sounds from fires and from recently burned areas. If they are not quiet during the program, they will miss many of the

sounds.) Students will be asked to describe their thoughts and feelings after the slide show is over. Explain that there are no "right" or "wrong" answers, that people respond differently to dangerous and emotional issues but should try to be informed about them.

3. Start the slide show. Advance the slides every 8-10 seconds.
4. When the show is over, give students time to write or make a drawing that records their thoughts and feelings.

Closure: Use student responses as the basis for a short brainstorming session. Ask for some responses, as single words or short phrases, and write them on a flip-chart. Ask for volunteers to share their art work. Save students' responses and the flipchart to use in the final activity of *FireWorks* (Activity VII-2).

SPARKS OF INFO:

Here is a detailed description of the "Visiting Wildland Fire" slide show. We provide it for your information, and in case you want to share some details about the show with your students. We don't expect you to "teach" this information.

Slide No.	Topic	Notes
1	Flames, down log	This fire is burning in large woody debris during a prescribed fire in lodgepole pine, Colorado
The first forest type is Ponderosa pine/Douglas-fir (PP/DF).		
2	Surface fire, PP/DF	In past centuries, ponderosa pine/Douglas-fir forests usually burned in low-severity surface fires like this one. Surface fires reduced surface fuels and duff, and killed most tree regeneration, without killing large, old trees. Thus they kept the forests open and unlikely to burn in severe fire.
3	Catface, PP	Large trees were not completely untouched by fire, however. Surface fires often killed the cambium part-way around the base of the tree, as occurred on this ponderosa pine. As the tree continued to grow, the damaged area showed as a triangular black scar with living wood curving in from its sides. (Photo is from Onehose Creek, Bitterroot National Forrest.)
4	PP branches	We might say ponderosa pines have a "love-hate" relationship with fire. Typical historic fires, burning in surface fuels, killed many ponderosa pine saplings and some mature trees, and scarred the trunks of survivors. But without fire, ancient old trees like this one are likely to die. They can't compete with dense Douglas-fir trees beneath them and may die of stress. They may be killed by fires that climb through the foliage of younger trees into their high, open crowns.

5	Pileated woodpecker	Each kind of forest in an ecosystem provides top-quality habitat for some animals. Pileated woodpeckers nest only in very large, old trees. The nest tree may be either living or dead, as long as it has a rotten center. This Pileated is feeding its family about 60 ft above above the ground in a ponderosa pine. In historic forests, some of the young pines eventually grew large and developed rotten centers, so woodpeckers were always able to find the right kind of tree to nest in. In today's forests, however, Douglas-firs outnumber pines, and neither species grows large because of competition for moisture and nutrients.
6	Arrowleaf balsamroot	Grasses and wildflowers are scorched and usually look dead the day after a surface fire, but the plants living in open ponderosa pine forests are perennials. This arrowleaf balsamroot grows back each year from a large, woody underground taproot. Surface fires provide a pulse of nutrients and reduce competition from young trees, so balsamroot often flowers profusely the year after fire.
The second forest type is Lodgepole Pine/Subalpine Fir.		
7	Lightning	In past centuries, forest fires were started by lightning and by Native Americans (for protection of camps and increased forage). Lightning still ignites most wildland fires in the northern Rocky Mountains and Intermountain area.
8	Severe fire, lodgepole pine	Lodgepole pines grow at middle and high elevations in the northern Rocky Mountains and Intermountain area. Here the summers are shorter and winters are colder than at low elevations, where forests are dominated by ponderosa pine and Douglas-fir. Although surface fires occurred here in the past, severe crown fires occurred in most forests. This photo shows a severe prescribed fire in lodgepole pine forest, Colorado.
9	Postburn, lodgepole pine	Immediately after a crown fire, the forest looks completely dead. The fire has consumed nearly all the trees' foliage and small branches. The soil is covered with ash. No longer held in place by living tree roots, it can erode rapidly. This photo shows the aftermath of crown fire in Wild Basin, Rocky Mountain National Park, Colorado, 1977 (?).
10	Fireweed	Unseen after the crown fire, however, are roots of perennial plants and millions of seeds. The severe Red Bench Fire in Glacier National Park, 1988, failed to kill roots of the perennial fireweed. This photo, taken in 1989, shows "mass flowering" of fireweed that sprouted from rhizomes after the fire. Fireweed also regenerates profusely from seed after fire. Seedlings are likely to "mass flower" two or three years after the burn.

11	Aspen sucker	Quaking aspens often grow in patches within pine forest. This aspen, in a stand surrounded by lodgepole pine forest, was top-killed by a prescribed fire in 1981. In 1982, it is already sprouting back ("suckering") from the roots.
12	Lodgepole seedlings	Lodgepole pine stores some of its seeds in cones that are sealed by resin and opened by the heat of fire. These cones are called "serotinous." After the 1988 Red Bench Fire in Glacier National Park, MT, lodgepole seedlings proliferated. This photo shows 10 to 20 seedlings per square foot four years after the fire.
13	Elk in lodgepole	Many animals use dense forests for shelter from storms and hiding cover. This elk is in a stand of lodgepole pine saplings.
14	Lodgepole burn mosaic	Crown fires in lodgepole pine forests typically burn in a patchy pattern, called a "mosaic," across the landscape. In this photo, burned patches look like black islands on the largely unburned slope.
15	Lodgepole forest mosaic	Decades after fire, the fire-caused mosaic is still visible. The lobe-shaped stand in the upper right, which has an almost moss-like texture when viewed from this distance, is dense lodgepole pine that became established after fire. Surrounding it is a taller, older forest.
The third forest type is Whitebark Pine/Subalpine Fir.		
16	Mixed sev. fire, whitebark	Whitebark pine grows on dry sites at middle and high elevations in the northern Rocky Mountains and Intermountain area. At high elevations, plants grow slowly and the summer is very short. Forest stands are interspersed with patches of rock and meadow, so fires spread unevenly and may even go out for lack of fuel. Where subalpine firs are growing beneath pines, however, foliage is continuous from the ground to the treetop. In these locations, fire can spread into tree crowns.
17	Whitebark fire scars	Whitebark pines do not have very thick bark, but these pines have survived at least one past fire. The same fire probably killed most of the subalpine firs in the stand.
18	Clark's Nutcracker	In late summer, flocks of Clark's Nutcrackers descend on groves of whitebark pine. They extract the white, fatty seeds from the pine cones, then bury the seeds in the soil. Throughout the winter and the following summer, Nutcrackers retrieve seeds from these "caches" to eat and feed to their young.
19	Whitebark seedling cluster	Nutcrackers don't retrieve all of the seeds from their caches. New trees grow from seed left in the ground. This cluster of saplings shows that many seeds were left in this cache.

20	Whitebark snags	Whitebark pines are killed by many things. This cluster of pines was probably killed by mountain pine beetles. White pine blister rust, a fungus accidentally introduced to North America from Europe, has killed about 96 % of the whitebark pines in the northern Rocky Mountains and Intermountain area. Dead trees may stand for decades on these dry sites, however, providing habitat for cavity nesters like the Mountain Bluebird.
21	Fire inside pine bole	Fire is a mystery to humans--destructive yet creative, powerful but ephemeral, and fascinating to watch. Here a prescribed fire burns the rotten wood inside a lodgepole pine, leaving a shell of bark behind.

Topic II. How Does Fire Work?
For students in grades 6-9

Basic Concept: Fire can occur only if oxygen, fuel, and heat are available. These three components are called the "fire triangle."

To investigate the fire triangle, students are given a description of wildland fire and the three required components ("legs" of the Fire Triangle). Then they remove the components experimentally, one at a time, and observe the effects on fire. Last, they learn how the fire triangle works in some wildland situations.

Background:

1. Read pages 10 through 28 in Patrick Cone's *Wildfire* (in the *FireWorks Library*) for more information on fire behavior in forests. *Wildfire* has excellent color photographs and diagrams.

2. Read pp. 10-11 in *Read About Fire,* in the *FireWorks Library,* for a simple, clear explanation of combustion.

3. Read pages 62-63 in *Wildfire* for a description of the fire behavior that occurs in a campfire. Clear color diagrams accompany this "Campfire Story."

4. For very detailed information and beautiful color diagrams about the chemistry and physics of wildland fire, read William Cottrell's *The Book of Fire* (in the *FireWorks Library*).

5. Jack deGolia's book *Fire - a Force of Nature* (in the *FireWorks Library*) describes the many ways a wildland fire can behave, depending on fuels, topography, and weather. See pages 8-13.

6. The Fire Triangle describes the basic chemistry and physics of fire behavior in simple terms. As fires grow larger and weather becomes erratic, however, fire behavior seems to take on a life of its own. It is then extremely powerful and unpredictable. Such fire behavior is described well for the 1988 fires of Yellowstone National Park, described with vivid photos on pp. 15-55 in *Yellowstone on Fire* (in the *FireWorks Library*).

Subjects: Physical science
Ecology
Mathematics (geometry)

Objectives: 1. To increase student skills in
- making & recording observations

- interpreting observations
- interpreting physical models
- applying new knowledge
- describing their discoveries

2. To increase student understanding
- of combustion
- of chemical change
- of wildland fire behavior, prevention, and suppression

This topic has four activities:

1. ***Meeting the Fire Triangle,*** basic principles of combustion
2. ***Testing the Fire Triangle,*** experimental investigation of fuel, heat, and oxygen requirements for fire
3. ***The Fire Triangle in Wildlands,*** a videotape segment depicting fire behavior in wildlands
4. ***People in Fire's Homeland,*** applying fire behavior principles to safety around homes in wildland areas

Extension and enrichment activities

Activity II-1.
Meeting the Fire Triangle

What's the Point? This lesson is a brief ***guided discussion*** that describes combustion and wildland fire in terms of things that students already know about fire. It may be possible to proceed to Activity II-2 without using this discussion, then challenge the students to construct the fire triangle from their own observations.

You will need about 20 minutes of classroom time plus the following:

In this trunk	***You must provide***
Fire Triangle display	*Fire Triangle* handout, p. Vis-2 (optional)
Tree Portrait poster	If students are going to make their own fire triangles, provide a copy of *Fire Triangle Kit*, p. Vis-3, three brads for each student, and several hole punches for the class.
Fuel Labels envelope	

Procedure: Explain to students that a fire cannot burn without fuel, oxygen, and heat. These are the three parts of the "fire triangle." Lead a discussion following the points below. This discussion can be quite brief and still prepare students adequately for the *FireWorks* activities. The Fire Triangle handout (p. Vis-2) can be used as a transparency to guide discussion or as a student handout. If you'd like to do a hands-on activity regarding the stable structure of a triangle, use the Fire Triangle Kit (p. Vis-3) or (sweet and edible) try the gumdrops-and-toothpicks activity in *FireWorks for Grades 1-5*, pp. E-19-20.

1. *What is fire?* Fire is a rapid chemical reaction that combines fuel and oxygen to produce heat and light.

PHYSICAL SCIENCE INTEGRATION: You can use either of the formulas below to describe the chemical reaction for combustion. Information about photosynthesis and respiration or the oxygen and carbon cycles, presented in many elementary and junior high science texts, can also be used here.

carbohydrate + oxygen + heat --> carbon dioxide + water vapor + heat + light

$C_6H12O_6 + 9\ O_2 + \text{heat} \rightarrow 6\ CO_2 + 6\ H_2O + \text{heat} + \text{light}$

2. *Burnable things surround us every day. Why aren't they on fire?* An external source of heat is usually needed to start combustion. Once a fire has started, it produces the heat

needed to continue burning. A fire can be put out if fuel, oxygen, or heat is removed. This idea is often depicted using a triangle (refer to the *Fire Triangle* poster). Remove any one of the three legs of a triangle, and it will collapse; remove any one of the required components of fire, and it will go out.

3. *What is the fuel in fires we are familiar with?* Most cars are fueled by gasoline, using an "internal combustion" engine; candles are fueled by melted wax, furnaces by natural gas or fuel oil, and campfires by wood.

SOCIAL SCIENCE AND ART INTEGRATION: Students can make a collage of familiar things that use combustion: Cars and gas appliances actually contain burning chambers. Electrical appliances often rely on combustion of coal. This collage can be used again in #6, when students are asked to identify source of heat for fires they are familiar with .

4. *What fuels a wildland fire?* In nature, fire's ***fuel*** is plant material. Use the *Tree Portrait* poster to discuss nature's fuels. Tape the colored labels from the *Fuel Labels* envelope to the tree portrait to illustrate these points: ***Tree canopies,*** high above the ground (red label), provide some fuel; these include tree *branches* and *leaves* (*needles* are a kind of leaf), tree *stems* and *trunks*, and *high shrubs*). Fuels that lie on or right above the ***surface*** (colored orange) include *dead and fallen needles, leaves, grass, dead wood, stumps,* and *low shrubs*. The main ***ground fuel*** is *duff,* the layer of dead, decaying plant material that makes up the top layer of soil (colored purple). It contains *decaying leaves, decaying wood,* and *roots*. Sometimes it is mixed with mineral soil (very fine rock particles), which won't burn.

5. *Where does the oxygen for fire come from?* Oxygen is plentiful in air. Students may be able to relate the "oxygen" part of the fire triangle to their fire-safety education: "Stop, drop, and roll" is one way to reduce the oxygen available to burning clothing. If a person should run with clothing on fire, the oxygen supply would increase and the fire would burn more intensely.

LIFE SCIENCE, MATH, & PHYSICAL SCIENCE INTEGRATION points: Oxygen comprises about 21 percent of the air we breathe. Nitrogen gas comprises 78%. Argon, carbon dioxide, and other gases comprise the remaining 1%. Oxygen is so plentiful that we use only about 20% of the oxygen in every breath we take. If we used it all, artificial resuscitation wouldn't work! Students can make a pie chart showing the chemical composition of air. This discussion point also provides an opportunity to refer to the oxygen and carbon cycles, photosynthesis, and respiration.

6. *What heat sources do we use to start fires?* Spark plugs in cars, pilot lights in appliances, and matches are some examples.

SOCIAL SCIENCE INTEGRATION: If students made a collage in #3, ask them to identify the source of heat for each of those fires.

7. *What provides heat for forest fires?* In wildlands, nature provides heat in lightning and volcanoes. Matches, untended campfires, and cigarettes are the sources of heat for many human-caused wildland fires. During the thousands of years when Native Americans were the only people living in North America, they often started fires. They used fire to make their campgrounds safe from fire and enemies, and to improve grazing for the wild animals that they hunted. After they obtained horses, they used fire to improve forage for their herds.

8. *How does wind influence fire?* Wind influences fire in many ways. Think about starting a campfire. If you blow on it, you provide extra oxygen and blow the heat toward the fuels, getting the fire to burn more intensely. If you blow too hard, especially across a small flame, you scatter the heat so much that the fire goes out. Wind also helps forest fires spread by drying out fuels and carrying burning embers ahead of the fire.

9. *Use the fire triangle to describe some ways to put out a fire.* To slow down a fire or put it out, at least one of the three components of the fire triangle must be changed. Think about ways that both large and small fires are controlled. When all the wax is gone from a candle or all the fuel is burned in a campfire, it goes out. A fireline, used to control forest fires, is simply a path cut through all of a forest's fuels - down to mineral soil. When the fire gets to the fireline, it runs out of fuel. When you throw water on a fire, you cut off oxygen and remove heat. You can also cut off oxygen by throwing dirt on a fire. Fire extinguishers and fire retardant dropped from airplanes remove heat and cut off oxygen from wildland fires.

10. *Optional: Have students assemble their own fire triangles.* Use the Fire Triangle Kit, p. Vis-3 or gumdrops and toothpicks (pp. E-19-20).

Closure/Transition: Explain: This discussion has provided some ideas about how fires work. Ideas, explanations, and even guesses about how things work are also called *hypotheses*. Scientists try to test their hypotheses, and students will be testing the Fire Triangle hypothesis in the next activity.

PLEASE NOTE: The next activity uses fire, so students need to dress appropriately. Read the *FireWorks Safety* poster with the class the day before doing Activity II-2.

Activity II-2.
Testing the Fire Triangle

What's the Point? This activity uses fires that students are familiar with - a burning match and a candle - to see if fire can occur without the components of the Fire Triangle. In the first experiment, a downward-pointing match and an upward-pointing match are burned. The downward-pointing match sustains fire until all of its fuel is burned to ash. (Ash is the mineral portion of wood, which doesn't burn.) Lack of fuel, then, is what puts the fire out. In contrast, the upward-pointing match goes out before its fuel is all consumed. The heat from the match disperses upward, so it heats the air above the flame but not the remaining fuel, which is beneath the flame. The upward-pointing match does not sustain fire as well as the downward-pointing one because of lack of heat. In the second experiment, students remove oxygen from a burning candle by pouring carbon dioxide on the flame.

You will need about 30 minutes of classroom time plus the following:

In this trunk	***You must supply***
FireWorks Safety poster	copies of handouts Vis-4 and 5
fire extinguisher	
Experiment 1:	
support stand (post and base)	wooden matches
support stand clamp (4)	wall clock with second hand
rod with alligator clip at each end (4)	paper towels for cleanup
burning tray (4)	
ashtray for burnt matches (2)	
15-cm rulers	
spray bottle, filled with water	
Experiment 2:	
1-qt freezer container (4)	wooden matches
votive candle (4)	dry ice (1-2 pieces about pingpong ball size for each group)-- available in most supermarkets[1]
ashtray for burnt matches (2)	
500-ml beaker (8)	
spray bottle, filled with water	tongs
	paper towels

Preparation: This is the first of several *FireWorks* experiments that use matches and fire. Prepare students the day before by going over the *FireWorks Safety* poster; this will enable them to dress safely. Students who do not follow safety rules (tying hair back, using goggles, wearing

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[1]If it is impossible for you to find dry ice, conduct this experiment baking soda and vinegar instead: Place the candle in a 1-qt freezer container (in the trunk). Then mix vinegar with baking soda. Immediately pour the resulting CO_2 gas (not the foam or liquid) over the burning candle.

cotton clothing) should not work close to fire. Conduct experiments on a surface that cannot be damaged by heat or fire. Make sure that ventilation is sufficient for smoke. Keep the *FireWorks* fire extinguisher nearby. Fill the spray bottles with water and place them in an accessible location. If you do the experiments outdoors, stay away from vegetation, including dry grass and bark chips. Be sure that burning embers do not reach flammable vegetation. Students handling matches and fire should be well supervised by adults.

Procedures:

These experiments are designed for teams of students. We suggest setting up 8 work stations - four for Experiment 1 and four for Experiment 2. Four teams can conduct Experiment 1 while the other four conduct Experiment 2. Then the teams can clean up their work stations and switch to the other experiment. Students can record data on the student handouts (pp. Vis-4 and Vis-5), which also describe experimental procedures.

Discuss the nature of dry ice with students. It is very cold and should only be handled with tongs. It is frozen carbon dioxide (CO_2). It is sublimating constantly from solid to gaseous phase. When they pour water over it, the sublimation accelerates. The fog that they see is a mixture of CO_2 and water vapor, which condenses from the air in proximity to the cold dry ice. The mixture "pours" from the beaker because it is denser than air-- both because of its temperature and because CO_2 is heavier than air.

PHYSICAL SCIENCE INTEGRATION: Students can check out the relative weights of carbon dioxide and oxygen by comparing the weight of a mole of the two molecules. Use the atomic weights below.

element	*atomic weight*
Carbon (C)	12 g
Oxygen (O)	16 g

A mole of CO_2 weighs	12 g + 2(16 g)	= 44 g
A mole of O_2 weighs	2(16 g)	= 32 g

Closure: Ask students to explain what puts the fire out in each experiment. Downward-pointing match: lack of fuel; upward-pointing match: lack of heat; candle: lack of oxygen.

Activity II-3.
The Fire Triangle in Wildlands

What's the Point? The Fire Triangle tries to capture the concepts underlying wildland fire behavior--a powerful, highly variable force of nature. When you're looking at a match or a candle, it looks simple. In wildlands, it usually isn't. Instead, it is complicated, intriguing, and dramatic.

In this activity, you do a demonstration of fire behavior in tree crowns (using "matchstick models" of forests), and students compare fire behavior in model forests on different slopes, with different arrangements of tree crowns. Then students view a 2-minute videotape clip of wildland fires burning in three layers of the forest--ground, surface, and crown fuels. They try to interpret the fires they see in terms of what they have learned about fuels, fire behavior, and the Fire Triangle.

OPTIONAL: Every fire produces smoke, which can impact visibility and human health. This lab and the next provide opportunities for students to measure and think about smoke from wildland fires. All information and procedures relating to smoke are enclosed in brackets.

You will need about 40 minutes of classroom time plus the following:

In this trunk	*You must supply*
Science Links, Module 2: Wildfire![2] videotape cued to 1:19 minutes	VCR and monitor
Tree Portrait with *Fuels Labels* attached (see Activity II-1, step 4)	wooden matches (lots)
Matchstick forest models (4) with nuts, bolts, and washers	metal trash can without liner
fire extinguisher	copy of handout Vis-6 for each student
burning trays (2)	[balance or scale]
spray bottle with water	[transparency of Vis-7 (to be used in smoke calculations)]
	[overhead projector & pens]

Preparation: Preview the video clip so you will know when to turn it off. The clip begins with "There are three kinds of fire..." (Right after the fire engines at 1:19 minutes) and ends with "Unchecked, unchallenged, the Yellowstone firestorm could have destroyed nearly everything in the Park" at 3:09 minutes. This statement, by the way, is a good one to use for "exercise" in critical

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[2]This videotape is provided courtesy of the Agency for Instructional Technology and South-Western Educational Publishing.

thinking (see step #12 below).

More Preparation: Ask four students to help. Give each a matchstick forest model (drilled square of masonite, 2 bolts, 1 nut-and-washer set) and 49 matches. Ask them to [weigh the matches and record their observation on handout/transparency Vis-7 (#1 a-d, first column), then] insert a match in every hole of the matchstick forest model, tips pointing up. [You'll use the weight data in steps #9 and 10 to calculate smoke emissions.]

Procedures:

1. Set up the four matchstick forests (prepared above) in burning trays on a heat-resistant surface. Let the first be level; to the second and third, attach the short bolt so slope is about 20 degrees. To the fourth, attach the long bolt so slope is about 40 degrees. Have a spray bottle and fire extinguisher nearby. Explain to students that the individual matches are supposed to represent trees that have flammable crowns, like the conifers of the northern Rocky Mountains and Intermountain area. In this demonstration, they will observe how slope and tree density affect the likelihood of crown fire in a forest.
2. Light the match tips along one edge of the flat "forest" and observe fire behavior. Then light the match tips along the top edge of a medium-slope forest and observe. Then light the bottom row of matches on the other medium-slope forest and observe. Finally, light the bottom row of matches on the steep forest and observe. Answer Questions 1-3 on handout Vis-6. Ask for explanations of what students have observed. [Heat travels upward, so the matches and trees uphill from a fire receive more heat than those below and are easier to ignite.]
3. Ask students to remove whatever remains of the matches from each matchstick board (they can use the nail in the kit), [then weigh them and record the weight on handout/transparency Vis-7 (#1 a-d, second column).]
4. Now ask students to brainstorm on how different numbers and arrangements of trees would affect crown fire spread, especially on a steep slope. List ideas or have students sketch their ideas on the board. Some possibilities: Put trees in every other row of the matchstick board; construct a forest with a fuel-break (like a road) in the middle rows; put trees in clusters with wide spaces between; put a row or two of burned trees (matchsticks) in the middle of the board.
5. With the class, select four of the ideas from #4. Ask a student to construct a matchstick forest to illustrate each idea. [As before, weigh the matches that go into each model and record the weight on Vis-7, 1 e-h, first column.]
6. Ask students to describe each model forest on their data sheet (first column in Questions 4-7, page Vis-6).
7. Burn the matchstick forests, one at a time. After each burn, ask students to record observations. [As in Step 3, remove whatever remains of the matches from each board, weigh them, and record the weight on Vis-7, #1 e-h, second column.]
8. Ask students to decide which tree arrangement might be most likely to burn in crown fire and which might best resist crown fire (p. Vis-6, #8).
9. [Explain: The crown fires you have been investigating are obviously very dangerous, but any kind of fire produces a subtle threat to human health: smoke. The tiniest particulates, those less than 2.5 micrometers ("microns") across, are the most damaging because they penetrate

deep into the respiratory system before lodging in the tissues. We can estimate how much of this fine-particled smoke a fire produces by using the results of some experiments. Scientists have measured the amount of fuel burned and the amount of smoke produced on many, many fires. Their experiments show that fine woody particles, like the matchsticks, produce about 4 grams of fine-particled smoke (called "PM 2.5" for "particulate matter less than 2.5 microns") for every kilogram of fuel burned. That can be expressed as 0.004 grams smoke/gram fuel, as in #1 on Vis-7.]

10. [Calculate how much smoke each of the matchstick fires produced (#1, Vis-7): Subtract the match weight after fire (second column) from the prefire weight (first column). Write it in the third column, "Weight burned." Multiply by 0.004 (fourth column) to get grams of smoke (last column). Discuss which fires produced the most smoke-- the fast-moving ones, the slow-moving ones, etc.]

Closure:

11. Point out the *Tree Portrait* with *Fuels Labels* attached (from Activity II-1, step 4). Explain: The matchstick forests illustrate the most spectacular kind of fire, spreading in tree crowns, but real fires actually spread in any of three fuel layers: the tree crowns, or "canopy" (red fuel labels), the surface (orange), and the ground itself (purple). The class will view video clips of these three kinds of fire behavior and discuss the fires [and their smoke production].
12. Show the video segment-- from 1:19 to 3:09 minutes.

INTEGRATION--CRITICAL THINKING: After the video, write on a flipchart page the statement that ends the clip: "Unchecked, unchallenged, the Yellowstone firestorm could have destroyed nearly everything in the Park." Ask students what they think about the statement. Write down their responses and, if you wish, save the flipchart to discuss in Activity VII-2, "Revisiting Wildland Fire."

13. Explain: People often talk about a fourth kind of fire, the "spot fire." Spot fires are caused by embers from crown fires, which can travel miles ahead of the main fire, crossing over roads and rivers, firelines and firefighters. Any time there are several fires in an area, caused by numerous spot fires or lightning strikes or any other source, they can influence one another and even merge into a large, severe "firestorm."
14. [Refer to the information about fuel consumption on p. Vis-7, #5. (The fuel consumption values in #5a are from a prescribed burn in aspen; the values in #5b and c are from a typical fire in ponderosa pine/Douglas-fir forest.) Calculate smoke production from these example fires: Multiply the second column by the third column, and write the result in the last column. Vis-7 refers to hectares, a metric unit of area about 2.5 times the size of an acre. Explain: How big is a hectare-- or an acre, for that matter?
    - A small basketball court, 35 X 84 feet, is 0.07 acre or .03 hectare.
    - A professional-size basketball court, 50 X 94 feet, is 0.11 acre, or 04 hectare
    - A football field, 360 X 160 feet, is about 1.3 acres, or 0.5 hectare.]

MATH INTEGRATION: An acre is 43,560 square feet. An acre is 0.404 hectare. Have students do the above calculations themselves. Even better, have them measure the size of their playground and calculate its size.

15. Ask students to compare ground, surface, and crown fires using what they saw in the video, what they observed as the matchstick-model forests burned, the information on Vis-7, and their understanding of the Fire Triangle. Use the ideas below to guide discussion.

	Question	Ideas to Explore
1	Which kind of fire seems to burn the greatest amount of fuel?	Crown fire seems to, but fires in peat and duff may actually consume more fuel. Look at the two values for duff consumption recorded in a prescribed fire in aspen groves (p. Vis-7, #5a).
2	In which kind of fire does the heat seem to be most intense?	Fire intensity quantifies how fast the fuel burns. Since crown fires usually burn a lot of fuel very rapidly, they are usually the most intense.
3	Which kind of fire seems to produce heat at the slowest rate?	Ground fires sometimes move only a few cm per day! They can burn through rainy weather and even smolder in deep peat bogs through the winter.
4	In which kind of fire may oxygen be in short supply?	Since there is less air underground than above, oxygen often limits the spread of ground fires. When a crown fire burns a large area very fast, oxygen right next to the fuels can be limited for a short time; then it sweeps in, and the fire expands almost explosively. A "blowup" like this is very powerful and very dangerous.
4	Which kind(s) of fire seems driven by wind?	Both surface and crown fires are often driven by wind. Crown fires often "drop to the surface" when the wind stops.
5	Which kind of fire produces the most smoke?	That depends on amount of fuel consumed. As #5 on Vis-7 shows, both ground and crown fires can produce huge amounts of smoke. However, the rates may differ. Crown fires usually move very fast, releasing all their smoke in a few hours. Ground fires can smolder for days. The effects of smoke on health and visibility depend on weather conditions, which determine whether the smoke goes into the upper atmosphere or is trapped near the land surface, where we breathe it in.
6	Which kind(s) of fire do you think damages plant roots the most?	Damage to plant roots depends on how moist the ground fuel (duff) is. If it is moist, a surface fire can pass through without burning deep into the ground and damaging plant roots. Ground fires can burn all but the deepest plant roots. Crown fires may damage roots simply because they produce so much heat that it can dry and burn the duff.

Activity II-4.
People in Fire's Homeland

What's the Point? Apply what students have learned about fuels, fire behavior, and the fire triangle to safety around homes in wildland areas.

Individually or in teams, students use a fire safety checklist from the National Fire Protection Association to assess the safety of homes shown in a collection of photos. AN ALTERNATIVE: You may cover the same information with the whole class by showing and discussing the *Wildland Homes* slides in the *Visiting Wildland Fire* slide carousel.

OPTIONAL: Like Activity II-3, this activity can be used to think about and discuss smoke impacts from wildland fires. Smoke-related supplies and procedures are in brackets[].

You will need about 20 minutes of classroom time plus the following supplies:

In this trunk	***You must supply***
People in Fire's Homeland photo collection (in *Teacher Box*)	copy of *Safety in Fire's Homeland* (p. Vis-41) for each student
[*Visiting Wildland Fire* slide carousel]	slide projector

Preparation: Decide how you want to cover this information. It can be done as a whole-class discussion (using the slides), as an individual writing assignment, or as a series of short presentations. The photo collection in the *Teacher Box* contains 30 photos in all-- three copies each of ten different homes (numbered on the back). You can ask students to work individually, then join the others who evaluated the same home and compare their assessments, then make one report or presentation.

Procedures:

1. Explain that students will use what they know about fire in evaluating the safety of homes that have been built in wildland areas.
2. OPTIONAL: With the students, scan through *Safety in Fire's Homeland* (p. Vis-41). Discuss concepts from *FireWorks* that illustrate the points in the checklist. Here are some **SPARKS OF INFORMATION** to help:

No.	Safety Checklist Point	*FireWorks* concepts
1	Is the roof metal or shingle? NOTE that home photo 2 shows shakes, 4 shows shingles, and 9 shows metal roofing.	Fires need fuel. Wood shakes, especially untreated ones, are great fuel.
2	Is firewood (and other wood) stored away from the house, not touching walls or deck?	Although big logs would be hard to ignite, they'd burn long and hot.

3	Are weeds cleared away from the sides of the house?	Weeds dry out in late summer. Dead, dry material burns easily.
4	Are tree limbs cleared from the roof and around the chimney?	A single match can start a fire. So can a spar from a chimney.
5	Are dead leaves and needles cleaned from the roof and rain gutters?	Fire needs fuel. Dead leaves and needles burn well.
6	Are trees and shrubs 5 m apart or more?	For fire to spread, heat must reach new fuels.
7	Are "ladder fuels" and low branches cleared from underneath big trees?	Heat rises. Saplings and low branches increase chance of crown fire.
8	Is the lawn watered and green, even in late summer?	Green fuels burn less readily than dead, dry fuels.
9	If the house is at the top of a slope, is the "safety zone" bigger than 10 m?	Heat rises....
10	Is the house on a flat place, or set back from the top of a slope?	Heat rises....
11	Is the road wide enough for a car going out to pass a fire engine going in?	

3. Explain the activity (individual work, writing project, discussion, presentation, or a combination). Here are **SPARKS OF INFORMATION** about the homes shown in the photos, keyed to the points on p. Vis-41. Question marks indicate answers that we felt were debatable because of the way the photo was taken.

Home No.	**We checked "Yes!" Looks safe because...**	**We checked "No!" Needs improvement because...**	**Can't tell or doesn't apply**
1	2, 3, 5, 6(?), 8, 10	1, 4(?), 7	9, 11
2	2(?), 5, 8(?), 10	1, 3, 4, 6, 7	9, 11
3	8, 10	1(?), 2, 3(?), 4, 5, 6, 7	9, 11
4	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	none	none
5	10(?)	3, 4, 6, 7, 8	1, 2, 5, 9, 11
6	3, 4(?), 7, 10	1, 2, 5, 6, 8	9, 11
7	1, 2(?), 4, 5, 6, 7, 10	3, 8	9, 11
8	1(?), 2, 10	3, 4, 5, 6, 7, 8	9, 11
9	1, 3, 5, 10	2, 6, 7, 8	4, 9, 11

10	2(?), 4, 8	3(?), 7, 9, 10	1, 5, 6, 11

Closure: If you do this activity on an individual basis, summarize the results.

[MORE INFORMATION ON SMOKE:
Explain: Even if a home is safe from fire, fires produce smoke that can affect our health and change the look of our scenic forests dramatically. The amount of smoke and dust in the air is measure in "PM 2.5," which means the amount of particulate matter 2.5 micrometer across or less. PM 2.5 is measured in micrograms per cubic meter ($\mu g/m^3$). Here are some slides that show how mountain scenery looks with different amounts of PM 2.5 in the air.

Show the *Smoke Impacts* slides in the carousel. All of these photos were taken in August and September, 1994. Smoke filled the Bitterroot Valley, where the photos were taken, from fires in Idaho and Washington state. The particulate levels in the slides are:

Slide	Particulates ($\mu g/m^3$)
1	5
2	25-35
3	35-45
4	65
5	95

]

Extension and Enrichment

1. If there is a recently burned wildland near your community, contact the land owner and plan a field trip. Prepare for the field trip by finding newspaper accounts or interviewing people who were there. You may also prepare by reading pages 54 through 61 in William Cottrell's *The Book of Fire* (in the *FireWorks Library*). While in the field, use this information to find clues about how the fire burned through the area. Many lessons in ***FireWorks*** can be greatly enriched by field experience.

2. Refer to the 1997 *Discover* article about lightning, in the *FireWorks Library.*

3. Check out your school's physical science textbooks and lab books for more descriptions of combustion and experiments for investigating it.

4. To further investigate air pollution and dispersion of pollutants, use the following demonstration of an *atmospheric inversion*. The only unusual material you will need is a small chunk of dry ice, obtainable from most supermarkets.
   - Set up an aquarium tank or a flat-bottomed plastic tub on your demonstration desk.
   - Inside, place a piece of cardboard (to insulate the bottom), then a square baking pan containing about 1 cm of water.
   - Add dry ice to the water. The cold, heavy CO_2 subliming from the dry ice cannot rise into the "upper atmosphere" because it is trapped by a blanket of lighter, warmer air. Like the CO_2 in the demonstration, smoke from a fire burning under an atmospheric inversion (warm air above the cold valley bottom air) won't disperse well.
   - Obtain a cup of boiling water. The hot air in the cup has colder air above it (not inversion conditions). Note how the water vapor is able to rise and disperse when an inversion isn't present.
   - Place the cup of hot water in the tank or tub. It will either form a mound of water vapor in the cloud of CO_2 or actually form a small column all the way up through the CO_2 into the warm air above. On cold days when sunlight finally warms the air near the ground, it can rise through the inversion layer just like the hot water vapor does in the demonstration. This can also happen when a fire is hot enough to "punch through" the cold air of an inversion and disperse into the warm air above.

Topic III. Neighborhood Trees

Getting acquainted with Intermountain & northern Rocky Mountain forests

Basic Concept: These activities introduce students to the nature of a forest and to nine native trees of the northern Rocky Mountains and Intermountain area. It provides a way for students to organize information about a science (botany), and it provides background that they will need for later activities.

Background: The trees studied here include "conifers," or cone-bearing trees, and also "broad-leaved" trees. Most conifers--and all of those studied here--have needles rather than broad, flat leaves. All of them except the larches keep their needles through the winter, so they are called "evergreens." The broad-leaved trees studied here drop their leaves in the fall and so are called "deciduous" trees, from a Latin word meaning "to fall off."

This topic addresses only trees, and only nine of the tree species native to the northern Rocky Mountains and Intermountain area. (The total is about about 20.) This geographic region contains more than a thousand native plants. To become acquainted with more of them, look at the *FireWorks* Notebook, the *Rocky Mountain Tree Finder,* and the *Field Guide to Forest Plants of Northern Idaho* (all in the *FireWorks* Library).

Subjects:
Botany
Ecology
Language

Objectives:
1. To increase student skills in
   - making observations
   - classifying information
   - applying new information
   - explaining their reasoning
   - working together to solve problems
2. To increase student awareness
   - of tree and other plant species
3. To increase student understanding
   - that a forest has many different kinds of plants
   - that plants have living parts (cells) and nonliving parts
   - that observations can be used to identify plants

This topic has two activities:

1. ***Tree Portrait,*** some traits that differ among trees
2. ***Mystery Trees***, organizing information about trees and using to identify them

Extension and Enrichment activities

Activity III-1.
Tree Portrait

What's the Point? This activity asks students to think about a tree's structure and living parts, and how they differ among tree species. Students identify parts of trees that are vulnerable to injury from fire. They also learn a little about forest soil. The tree and soil characteristics studied in this activity are the subject of the experiments in **Topic IV, Tough Trees.**

You will need about 15 minutes of classroom time plus the following:

In this trunk	***You must supply***
Tree Portrait	transparent or masking tape
Tree & Soil Parts labels	Copy of *Tree Parts Glossary* (p. 8) for each student
Fire Targets labels	

Procedures:

1. Display the *Tree Portrait,* a photo of a ponderosa pine, at the front of the classroom. Explain: "Conifers" like this one have needle-shaped leaves rather than broad, flat leaves. All conifers in our area except the larches keep their needles through the winter, so they are called "evergreens." In this topic, students will also study some "deciduous trees," which have broad leaves that fall off each autumn.
2. Distribute the *Tree & Soil Parts* labels and the *Fire Targets* labels among students.
3. Give a copy of the Tree Parts glossary (p. Vis-8) to each student.
4. Ask the students who received *Tree* and *Soil Parts* labels to look up their term in the glossary, read the description there, and prepare to describe it to the class.
5. Ask the students who received *Tree Targets* labels to read the glossary and circle the name of each tree part listed there that is alive (that is, has living cells).
6. Ask each student with a *Tree or Soil Parts* label to find his or her "part" on the *Portrait,* tape the label onto the *Portrait* in the correct place, and explain what that part is. Have students attach the *cambium, bark, and wood* labels to the tree cookie photo, so the relationship between these three parts of the tree trunk is clear. The three *bud* labels should point to a branch tip, the tree's top, and the root tips.
7. Ask each student with a *Fire Target* label to tape it onto a *Tree Part* that is "alive," or "has living cells." Targets should point to needles, buds, cambium, seeds, and roots.
8. Discuss the following:
   - The *Fire Targets* identify the parts of the tree that can be killed by fire.
   - Unless a fire kills many of the living cells of a tree, the tree will survive.
   - If a tree is killed by fire but its seed survives, the species will probably be present in the new forest that develops after the fire.
   - Duff and mineral soil are not alive. However, if they burn, the tree roots growing in them may be killed.

Closure/Transition: Have students become a living model of a tree. The directions here are written for a class of about 25, but you can adjust the numbers so everyone participates.

1. Ask the tallest two students to stand back-to-back, with their arms stretched high and reaching

slightly outward. Explain that these are the tree's branches and leaves, which must gather energy from sunlight and turn it into nutrients that all living cells in the tree can use. Ask them to pantomime their work by wiggling their fingers. If you have a sturdy stool for these students to stand on, the activity will work better.

2. Ask 6 students to stand in a circle around the "branches," front-to-back, with their right sides all to the inside and their left sides to the outside. Explain that these students are the "heartwood" of the tree; their *only* living cells are on their left sides. (You can explain that they are *xylem* cells.) These cells have the job of lifting water and dissolved minerals from the roots to the branches of the tree. Ask them to pantomime this work, keeping their right sides completely still.
3. Ask 4 more students to stand shoulder-to-shoulder in a circle around the "heartwood," facing out. Explain that these students represent the living cells that carry nutrients throughout the tree-- from leaves to branches, stem, and roots, in any direction that nutrients need to be delivered. Ask them to pantomime this work. (You can explain that these are *phloem* cells.) Together with the water-lifting cells of the heartwood, they form the tree trunk's very important living layer, the *cambium*.
4. Ask 5 more students to stand shoulder-to-shoulder outside the phloem cells, facing in. Explain that they represent the tree's bark, which contains mostly dead cells and protects the cambium from injury. Ask them to look very strong and stand very still to show their job.
5. Ask the remaining students to lie on the floor-- feet at the base of the tree, heads and arms spread out along the ground. Explain that they are the roots, with their tips and tiny hairs growing out, searching for water. They can spread their hair out on the floor and wiggle their fingertips to show their work.
6. Ask all the students to do their work at once. They will see that a living tree is a very busy mixture of living and dead parts, all with important work to do.

Activity III-2.
Mystery Trees

What's the Point? This activity has two parts. First, students describe a tree species by studying specimens and photos of nine tree species common in the northern Rocky Mountain and Intermountain area. Then they use the observations of other students to identify a second tree species, their "mystery tree." The two parts of the activity can be completed in two separate sessions.

The tree specimens in *FireWorks* are permanently labelled with a code letter. The key linking letter codes with species names is below. To figure out the code, take the third letter of the species' common name ("a" for black cottonwood), then go to the next letter of the alphabet ("b"). The code letter for quaking aspen starts with the fourth letter of its common name, "k."

black cottonwood	B
Douglas-fir	V
Engelmann spruce	H
lodgepole pine	E
quaking aspen	L
ponderosa pine	O
subalpine fir	C
western larch	T
whitebark pine	J

You will need about 50 minutes of classroom time plus these materials:

In this Trunk	*You must supply*
laminated tree species name signs (9)	1 copy, *Species Assignments* record (p. Vis-9)
tree cones or flowers[3] (7)	9 copies, *This Tree's No Mystery* data sheet (p. Vis-10)
Tree trunk sections showing bark (9)	large grocery bags (9)
photos collections of tree, foliage, bark, and cones (9)[3]	9 copies, *Tree Habitat* data sheet, p. Vis-11
plastic-wrapped branch from each species	straight pins

[3] Photos and specimens of aspen and cottonwood flowers may not be available until next spring. Some collections may have specimens not mentioned here, such as beetle-riddled bark. **If possible, cut fresh branches from these tree and attach the square tree-code labels to them. Use the plastic-coated branch specimens for species that you can't get live branches for.**

laminated tree code labels--1-letter square (9)

15-cm rulers (9)

Feltboard Kit for Ponderosa Pine Forest

Feltboard Kit for Mystery Trees[4]

Preparation: Staple a laminated tree code label (the 1-letter squares) onto each grocery bag. Into each bag place the tree trunk section, branch specimen, cone collection, and photo collection for that species. Also put in the laminated tree species name and any additional specimens with that label (beetle-riddled bark, etc.).

From the Feltboard Kit for Ponderosa Pine Forest, remove the background; pin or tack it up in your classroom, preferably near a table where the Mystery Trees specimens can be displayed at the end of this activity. From the Feltboard Kit for Mystery Trees, attach the pieces representing Sasquatch Peak (brown) and Footprint Creek (blue) to the feltboard. (See photo below.) Attach the "elevation bar" along the right-hand edge of the feltboard. Attach the "moisture bar" along the bottom. Attach the two transparent labels that inciate site moisture diagonally between the creek and the horizon. (See photo below.) After placing these pieces on the feltboard, secure them with straight pins.

Procedures:

7. Explain to students: Each team will describe a tree species and then use the observations of their classmates to identify a "mystery species." Explain that only 9 species are currently included in this activity, but there are about 20 native trees in the forests of the northern Rocky Mountains and the Intermountain area.
8. Designate 9 areas or tables in the classroom as "observation sites." Assign a team of students to work at each site.
9. Give the students at each observation site a ruler, a data sheet (p. Vis-10), and a grocery bag with their collection inside. On your copy of the ***Species Assignment*** sheet (p. Vis-9), note the species assigned to each group. You will use this list in step #8 to avoid giving any team the species they just described as their "mystery tree."
10. Ask each team to complete the data sheet describing their species. Ask them to write neatly, so other students will be able to read their observations.
11. When each team finishes its work, visit their observation site. Pick up the species name label. Check the data sheet for completeness and accuracy. Ask the team to revise it, if

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[4]Contents: 1) location labels (Forest, mountain, and creek) for this fictitious national forest, 2) red bar with elevations marked, 3) purple bar with need for moisture marked, 4) blue "creek," 5) red yarn, 6) one labelled tree outline and one arrow for each tree species, 7) green labels for forest types.

necessary, so it will be useful for identifying mystery trees.

12. After a team's data sheet is completed satisfactorily, ask them to place their collection back in the grocery bag and return it to you.

This is a good time for a break in the activity.

13. Make nine photocopies of each data sheet; collate them so each team will have a complete collection.
14. Distribute the grocery bags of specimens again. Use your notes on the *Species Assignment Sheet* (step #3) to avoid giving any team the species they identified in steps #3-6. Explain: This bag contains the team's "mystery tree."
15. Ask each team to identify their mystery tree by referring to the observations of their classmates (the photocopied data sheets).
16. Ask each team to report the identity of their mystery tree to the class and explain what clues they used to figure it out. Ask the students who prepared the original data sheet to verify or correct the identification.

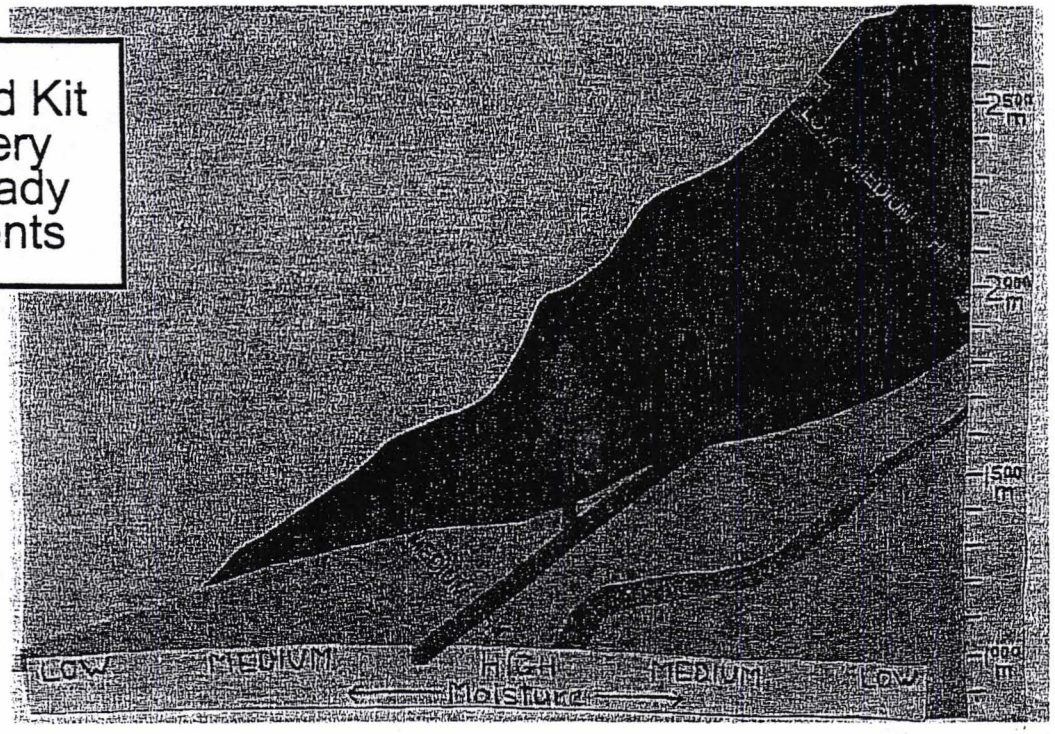
This is another good time for a break.

Closure:

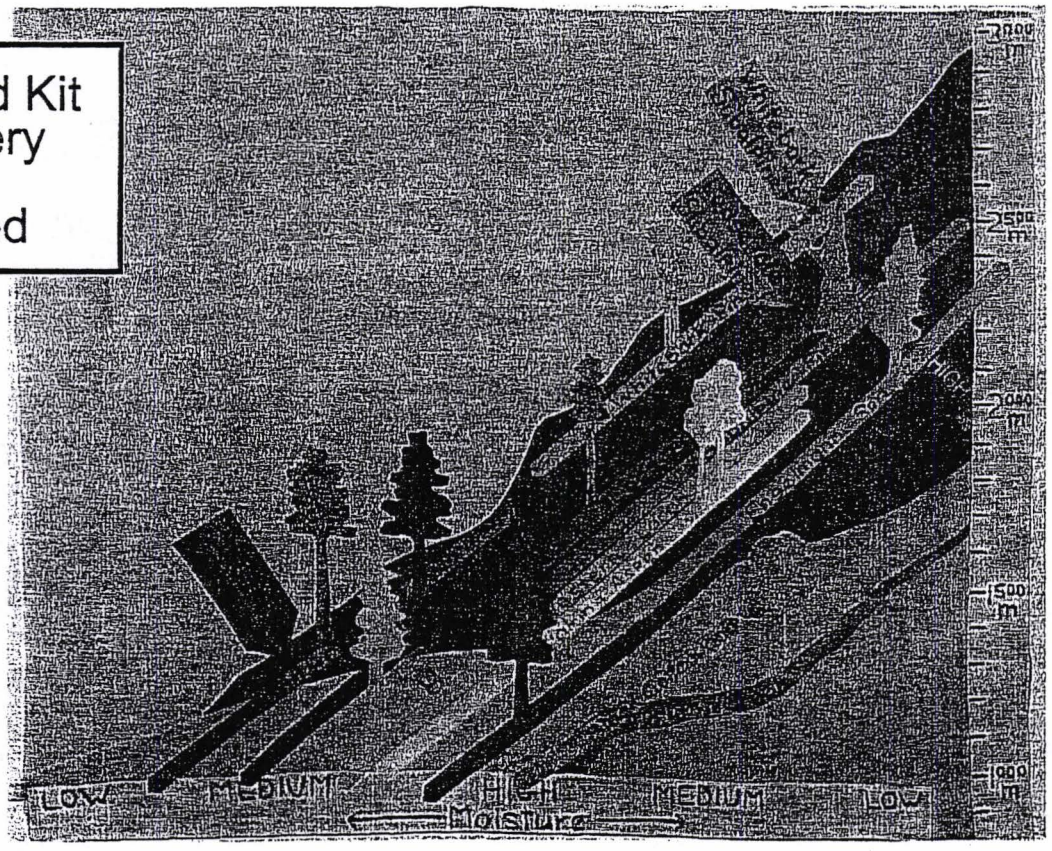
17. Give each team a copy of the*Tree Habitat* data sheet, the color-coded felt tree outline for their species, and the long felt arrow for their species. Ask them to use the data sheet to figure out where to position their arrow on the feltboard to show the area in the fictitious Bigfoot National Forest where the species is most common. Use the felt arrow and outline for grand fir to illustrate.
18. Ask students to attach the felt arrow for their species to the feltboard. After the arrows are attached, have them attach the tree outlines too. The trees look best when the tree base is placed on the arrow for that species. See the photo below.
19. Return the tree species labels to the student teams. Have them display their specimens, with names, on the table under the feltboard. They will refer to these in **Unit IV. Tough Trees**.
20. Explain to students: The feltboard shows how complicated a typical forest is in this geographic area. As they continue with *FireWorks* activities, they will focus on just three kinds of forest: ponderosa pine/Douglas-fir, lodgepole pine/subalpine fir, and whitebark pine/subalpine fir.
21. Ask students to place the three felt pointer-labels for these three forest types on the feltboard (see illustration). These are only the most common tree species in the forest type; you can use the feltboard to discuss other species likely to occur. For example, western larch and Douglas-fir can occur in lodgepole pine/subalpine fir forest.... Lodgpole pine commonly occurs together with whitebark pine.... If you move from a ponderosa pine/Douglas-fir forest to a place just slightly more moist, you are likely to find western larch there.

PLEASE NOTE: The next activity uses fire, so students need to dress appropriately. Read the *FireWorks Safety* poster with the class the day before doing Activity II-2.

Feltboard Kit for Mystery Trees ready for students



Feltboard Kit for Mystery Trees completed



Extension and Enrichment

1. Ask students to use a dichotomous key in the *FireWorks* library (either the *Rocky Mountain Tree Finder* or the *Field Guide to Forest Plants of Northern Idaho*) to identify another mystery tree in your school area or near their home, then report on it to the class.

2. Contact a forest land owner and plan a field trip. Ask students to identify the trees they see. If the land owner agrees, ask students to collect leaves from other plants - one leaf from each "kind" of plant. Remind students that grasses and mosses are plants. In the field, or later in the classroom, ask students to compare leaves from their collections, put similar ones (possibly from the same species) together, and estimate how many plant species they found on the field trip. Please note that many lessons in ***FireWorks*** can be greatly enriched by field experience.

3. Write and illustrate a booklet about the life of a tree for First Grade students.[5]

4. Explore music, poetry, and song about trees. Create a dance or illustrate the poetry.[3]

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[5]Thanks to "Investigating Your Environment," from the U.S.D.A. Forest Service, for these activities.

Topic IV. Tough Trees
An investigation of tree traits in relation to fire
for students in grades 6-9

Basic Concept: Many plants and animals have ways to survive fires. Many also have ways to reproduce after fire, even if they are killed. In these activities, students look at several traits of trees. They compare traits that differ from one kind of tree to another. They hypothesize about traits that make trees vulnerable to fire, and they make observations that help them accept or reject their hypotheses.

Background:

1. Read pages 29 through 34 in Patrick Cone's *Wildfire* (in the *FireWorks* library) for more information about fire effects on trees and forests. *Wildfire* has many excellent color photographs and diagrams.

2. Jack deGolia's book *Fire - a Force of Nature* (in the *FireWorks* Library) describes the main concepts of research on fire effects. See pages 28-30.

3. For more information and color diagrams describing the effects of severe fire, read pages 53-61 of William Cottrell's *The Book of Fire,* in the *FireWorks* Library.

Subjects:
Physical science
Botany
Ecology
Language
Mathematics

Objectives:

1. To increase student skills in
- observing
- solving problems
- stating and testing hypotheses
- describing observations
- explaining reasoning
- applying results of experiments

2. To increase student understanding
- that different kinds of trees respond differently to fire
- that it is possible for trees to survive forest fires
- that it is possible for trees to reproduce even if they do not survive fire

This topic has four essential and one optional activities:

1. ***Will it Burn?*** experimental investigation of some traits that relate to fire resistance in trees
2. ***Tree Skin***, investigation of heat effects on tree bark
3. ***Recipe for a Lodgepole Pine Forest***, investigation of serotinous pine cones
4. ***Tinker Tree Derby***, investigation of tree and forest architecture and vulnerability to fire

Optional Integration & Closure: ***Designer Trees***

Extension and Enrichment

Activity IV-1.
Will It Burn?

What's the Point? In four experiments, students investigate the effects of fire on different parts of a tree:

Experiment 1	Needles
Experiment 2	Buds
Experiment 3	Branches
Experiment 4	Roots

In each experiment, students try to burn two kinds of natural fuels; they decide which kind is harder to burn and think about why.

The Fire Triangle (**Topic II**) describes what is essential to start a fire (fuel, oxygen, and heat). In this group of experiments, refer to the Fire Triangle to help students explain why one set of materials is harder to burn than another. "Burnability" is related to the mixture of oxygen and fuel and the intensity of heat provided. In these four experiments, roughly the same amount of heat is provided to each set of materials - flame from a single wooden match, applied to a double layer of crumpled newspaper.

AN ALTERNATIVE WAY TO PRESENT the same information, a simpler lab that can be conducted outdoors, is "Bucket Brigade" in *FireWorks for Grades 1-5*, pp. E-24-26.

You will need a minimum of 30 minutes of classroom time, plus the following:

In this trunk	***You must supply***
burning tray (4)	wooden matches
oven mitts (4)	water for spray container(s)
spray container (2)	newspaper cut into sheets about 25 X 35 cm (1/4 of unfolded, open "page")
safety goggles (4)	
ashtray for burnt matches (4)	metal trash can (without liner)
fire extinguisher	copies of student handouts Vis-13 through Vis-16
15-cm rulers (4)	paper towels for cleanup
transparency Vis-12	overhead projector

FireWorks provides enough materials and supplies for four teams to do each experiment. You will need one packet of each of the following "fuels" for each team doing each experiment.

Experiment	**Fuel**
1	dead, dry needles of ponderosa pine
1	green needles of ponderosa pine
2	bud & branch tip of Douglas-fir
2	bud & branch tip of ponderosa pine
3	fine branches (<1/2 cm thick)
3	thick branches (>2 cm thick)

4	duff (peat)
4	mineral soil (sand)

Procedures:

These experiments use fire and wildland fuels. Prepare students the day before by going over the *FireWorks Safety* poster; this will enable them to dress safely. Conduct experiments on a working surface that cannot be damaged by heat or fire. Make sure that ventilation is sufficient for small amounts of smoke. Keep the fire extinguisher nearby. Fill the spray bottles with water and place them in an accessible location. If you do the experiments outdoors, stay away from vegetation, including dry grass and bark chips. Be sure that burning embers do not reach flammable vegetation. Students handling matches and fire should be well supervised by adults. Everyone working directly with fire should wear safety goggles (in *FireWorks* supplies).

FireWorks contains materials sufficient for four work stations. Enough fuels are included for four teams to do each experiment. However, since these experiments can produce quite a bit of smoke, you may want to have only one or two teams do each experiment, then show their burned materials and report their results to the class.

Some of the details for these experiments are hard to describe verbally. Show students how to crumple pieces of newspaper separately and lay them on the burning tray. Show them Vis-12, the transparency about how to ignite the newspaper for their experiments (two corners on one side, preferably the "long" edge). Procedures for the four experiments are written on the student data sheets (pp. Vis-13 through Vis-16). Here are a few notes on each:

Experiment 1. Dead vs. Green Needles. Because a lot of heat is needed to dry fuels out before they can burn, we expect dry material to burn more easily than moist material. The dead needles in Experiment 1 have about the same moisture content as their surroundings, which may be as low as 5% of their weight. Green needles, on the other hand, usually contain moisture at least equal to their own weight.

Experiment 2. Tree Buds. In general, the more fuel surface exposed to oxygen and heat, the more easily the fuels burn. That's why people use crumpled newspaper instead of piles of newspaper to start a campfire. This idea leads us to expect thick buds to burn less easily than tiny buds and twigs.

Experiment 3. Large vs. Small Twigs. As in Experiment 2, the more fuel surface exposed to oxygen and heat, the more easily the fuels burn, so we expect thick buds and twigs to burn less easily than tiny buds and twigs.

MATHEMATICS INTEGRATION: The surface area of fuels that is exposed to oxygen and heat influences fire behavior strongly. You can use Experiment 3 to quantify this property by altering the procedures like this:

In Step 1, obtain equal weights of small and large twigs. (Take 1 or 2 large twigs, weigh them; take enough small twigs to have about the same weight.) Measure the length and diameter of each twig; use these to calculate the volume ($V=\pi r^2 L$) and surface area ($A=2\pi r^2+L\pi d$) for each. Compute the total volume and surface area for each samples. Express this as a ratio, surface area/volume.

Experiment 4. Mineral soil does not burn because it contains no organic matter - that is, no fuel. Roots growing deep in mineral soil are less likely to be damaged by fire than roots growing in duff.
Note that this experiment is not strictly comparable to the previous three, since it uses five layers of newspaper and puts newspaper below and above the fuel. We use this procedure because duff is more difficult to ignite than the other fuels in these experiments.

Closure: Not every student is likely to complete every experiment. Therefore, review the four experiments with the whole class and use the components of the Fire Triangle to explain results.

Activity IV-2.
Tree Skin

What's the Point? Bark thickness influences a tree's ability to insulate its cambium from heat. It is not the only influence, of course; presence of pitch and bark density also influence a tree's resistance to heat damage, and other parts of a tree (buds, roots, seeds) are also vulnerable to fire, as students learned in Activity III-1.

This activity is designed as a demonstration for the whole class. *FireWorks* provides ***only one*** set of supplies.

You will need about 20 minutes of classroom time and the following:

In this trunk	***You must supply***
hair dryer	masking tape
digital thermometer	graph paper for each student
1.5 pound coffee can	wall clock with second hand
brown fabric rectangle	5 layers of newspaper large enough to cover the coffee can
quilted fabric rectangles (5)	
data sheets from *Mystery Trees* (Activity III-2)	
tree bole samples from *Mystery Trees* (Activity III-2)	overhead projector & pens
15-cm ruler	data sheet for recorder (p. Vis-17)

Preparation: Check the battery of the digital thermometer. Have a 9-V battery and a screwdriver on hand. Ask one or two students to refer to the data collected in *Mystery Trees* (Activity III-2) and write on the board each species' name and its bark thickness, in cm. They may want to re-measure bark thickness on the tree trunk specimens. Use masking tape to attach 5 layers of newspaper to the coffee can.

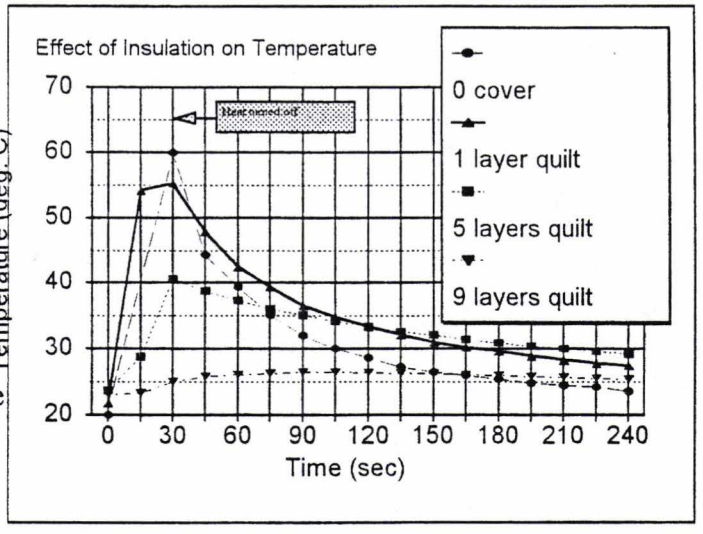
Procedures:

1. Set the papered coffee can on a demonstration bench so the class can see it. Place the cloth samples on one side.
2. Plug the thermocouple wire into the digital thermometer. Place it on the other side of the coffee can.
3. Plug in the hair dryer.
4. Assign students to the following tasks:
   - Heater: Holds the hair dryer 5 cm from the *surface* of the coffee-can tree (he or she should measure the distance with a 5-cm ruler). Keep this distance constant, no matter how much insulation is placed between the tree's *surface* and the thermocouple itself. You are measuring the ability of the "tree" to insulate its cambium.
   - Reader: Holds the digital thermometer so students can see it and calls out "official"

temperature every 15 seconds

- Timer: Calls out "time" every 15 seconds during the 4-minute experiment, as follows: "Go"... then "15"... "30"... "45"... "1 minute"... "15"... "30"...
- Recorder: Records temperature on transparency at start of experiment and every 15 seconds throughout the 4 minutes

5. Use masking tape to attach the thermocouple to the newspaper covering the can. The newspaper represents wood. The brown cloth, with various levels of insulation, represents tree bark.
6. Do the following steps six times - once with only the brown cloth covering the thermocouple, then once with each set of quilted materials (brown side out). You may want to do one of these experiments with the whole class, then have student teams do the others. Or you may want to do only 3 repetitions (0, 4, and 10 layers of insulation).
   a. Reader, turn the digital thermometer "on," and call out the temperature.
   b. Recorder, write this temperature down at "time=0."
   c. Timer, say "Go"... Then, every 15 seconds throughout the experiment, call out the time.
   d. Heater, when the Timer says "Go," turn the hair dryer on the "high" position. Hold it 5 cm from the brown cloth until the Timer says "30." At 30 seconds, turn it off.
   e. Recorder, write the temperature that the reader calls out every 15 seconds on the data sheet.
7. Photocopy the data and ask students to graph it, with "Time" in 15-second intervals on the X axis and "Temperature" on the Y axis. See the illustration at right for an example.



Ask the class to discuss explain the time-temperature traces on their graphs. Main points to notice: The thinner the insulation, the faster the thermocouple temperature rises and the higher it goes. The thicker the insulation, the slower the temperature rises and falls; in fact, the temperature may continue to rise even after the heat source (hair dryer) is removed.

Closure: Use the following questions to guide further discussion.

Do you think that thick bark protects a tree from heat or adds to heat damage? Explain.	Thicker bark usually means greater protection because bark contains a lot of air spaces that conduct heat slowly. (Air is a good insulator. That is, it conducts heat poorly.) If the source of heat is very long-lasting, however, even thick bark can't protect the tree. The bark will eventually become hot or even burn. This will heat and kill the cambium. Thick bark warms up slowly, but it also cools slowly, thus holding heat longer than thin bark. If high temperatures are reached at the cambium layer, thick bark sustains them longer and can damage the tree in this way.
Based on bark thickness alone, rank the eight trees studied in *Mystery Trees* according to their resistance to damage from fire.	Depends on the specimens in your trunk. Ponderosa pine, western larch, and Douglas-fir are well known for their thick bark, especially when old; subalpine fir and quaking aspen usually have thin bark.
What other properties of bark might make some trees more vulnerable or more resistant to damage from fire? How could you test these hypotheses?	Pitch on the bark makes it flammable and less fire-resistant. Scars from old wounds may have little or no bark covering them, so the area around them has little protection. Different tree species have bark of different colors and densities, which affect heat transfer.

Activity IV-3.
Recipe for a Lodgepole Pine Forest

What's the Point? Lodgepole pine forests cover very large areas in the northern Rocky Mountains and the Intermountain area. Most of these forests began after fire some time during the past 150 years. Many of the fires were very severe, at least in patches. These forests will probably burn again in the next century. A few years after they do, most burns will be covered with thousands of lodgepole pine seedlings. Why? This species stores much of its seed in resin-sealed cones that stay on the tree for many years. They open when heat melts the resin and frees the seeds.

This activity has four parts: (1) Treat the cones with hot water so they will open. (2) A day or more later, remove seeds from cones and count them. (3) Prepare seed and plant it. (4) Study germinating trees.

You will need about 20 minutes of classroom time plus the following supplies:

In this trunk	*You must supply*
lodgepole pine cones	very hot water (boiling water stored in a thermos will do)
cones examined in *Mystery Trees* (Activity III-2)	2-4 aluminum pie tins
How many seeds? transparency (Vis-19)	paper plates
	copies of *Recipe for a Lodgepole Pine Forest* (handout Vis-18) for students
	overhead projector and pens for transparencies
	potting soil
	paper cups
	copies of *Lodgepole Pine Data* (p. Vis-20) for students
	OPTIONAL: copies of *Lodgepole Pine Challenge* (handout Vis-21) for students

Procedures:

1. On the board, make two columns: *Hypotheses* and *Experimental Designs*.
2. Distribute lodgepole pine cones -at least one per student.
3. Ask students to notice that these cones are closed, unlike the cones from most other trees.

Pass around the cones used in *Mystery Trees* (Activity III-2) for comparison. Explain that some lodgepole pine cones do open at maturity, unlike those in this activity.

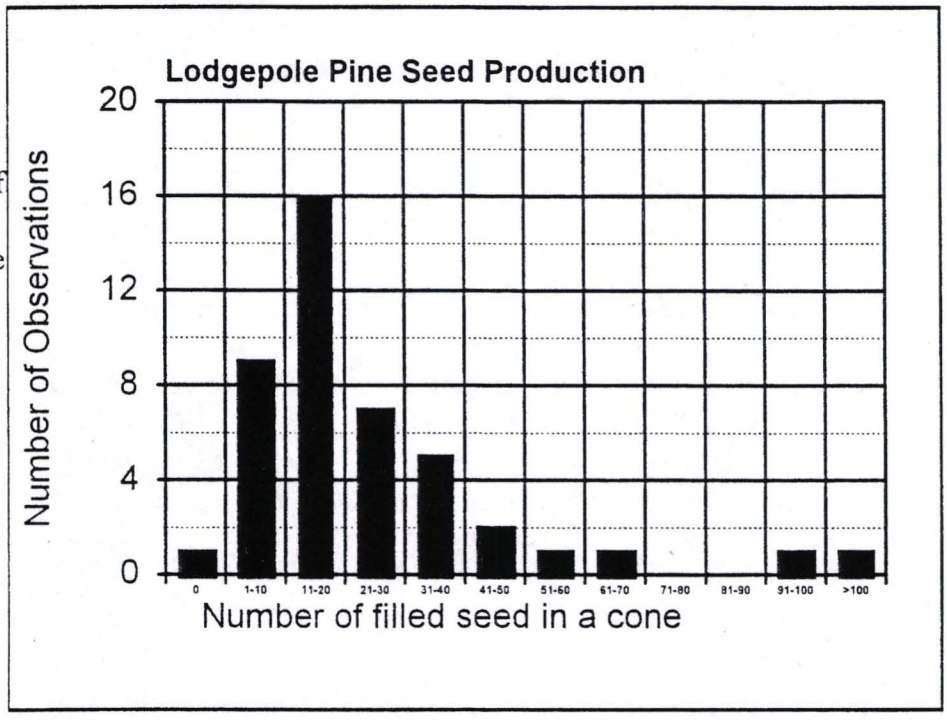
4. Ask for ideas about how the closed lodgepole pine cones might be opened in nature (*hypotheses*), and how they could test these ideas (*experimental designs*). Write the hypotheses and experimental designs on the board. Hope that "heat" or "fire" is on the list.

SCIENCE INTEGRATION: Students are likely to come up with some hypotheses that can easily be tested in the classroom. "Animals pound or bite them open"... and "Water opens them..." are two possibilities. If you can, take the time to test these hypotheses and discuss the results.

6. Test the hypotheses related to heat by using *Recipe for a Lodgepole Pine Forest* (directions on handout, p. Vis-18).

Closure:

Use students' data to make a histogram on transparency Vis-19, showing the frequency of various numbers of seeds. How common are trees with no seeds? What is the largest number of seeds? Calculate the average and median, and discuss the meanings of these numbers. Ask students why they think productivity varies so much. Genetics, location, soil, and weather in the past couple of years all affect cone and seed production.



MATH INTEGRATION: Use the *Lodgepole Pine Facts* and observations from your experiments to answer the *Ecology Challenge* questions on the student handout (p. Vis-21).

PLEASE NOTE: The next activity uses fire, so students need to dress appropriately. Review the *FireWorks Safety* poster the day before doing Activity IV-4.

Activity IV-4.
Tinker Tree Derby

What's the Point? The arrangement of branches and needles on a tree is part of the tree's structure. The arrangement of trees in a forest is part of a forest's structure. You could call these arrangements the "architecture" of the forest. They affect how easy or hard it is for a fire to burn the trees. In the ***Tinker Tree Derby***, students investigate forest architecture in relationship to fire.

You will need about 45 minutes of classroom time plus the following supplies:

In this trunk	***You must supply***
Burning tray (4)	metal trash can
spray container (2)	newspaper cut into sheets about 25 X 35 cm (1/4 of unfolded, open "page")
safety goggles (4)	
ashtray for burnt matches (4)	
10-m measuring tape	scissors
oven mitts (4)	water for spray container
fire extinguisher	wooden matches
support stands (4)	hole punches
rod segments (about 20 per stand)	copies of student handouts (p. Vis-22)
Tinker Tree Derby Grand Champion rosettes (4)	calculators
	paper towels for cleanup
Tinker Tree Derby Champion badges (4)	copies of *How Tough?* handout (p. Vis-23)
	overhead projector
Illustration of newspaper setup and ignition transparency (Vis-12)	transparency pens
How Tough? transparency (p. Vis-23)	

Procedures: The Tinker Tree Derby sets up a competition among student teams. They are required to design a "tinker tree" from ring stand, wire, and newspaper that can withstand fire passing beneath it - an "underburn." However, they must also make sure that their tinker tree has plenty of leaves for growing and producing seed.

FireWorks contains enough materials for 4 teams of students to work simultaneously.

The Derby has two phases. In Phase 1, every team submits a tinker tree for the competition to see which design can withstand underburning but also has the greatest total length of leafy branches. In Phase 2, the "survivors" from Phase 1 are tested to see if they can survive fire even if "tinker saplings" are growing under them.

This *FireWorks* experiments uses fire. Prepare students the day before by going over the *FireWorks Safety* poster; this will enable them to dress safely. Conduct experiments on a working surface that cannot be damaged by heat or fire. Make sure that ventilation is sufficient for small amounts of smoke. Keep the *FireWorks* fire extinguisher nearby. Fill the spray bottles

with water and place them in an accessible location. If you do the experiments outdoors, stay away from vegetation, including dry grass and bark chips. Be sure that burning embers do not reach flammable vegetation. All people working directly with fire should wear safety goggles (included in *FireWorks* supplies). Students handling matches and fire should be well supervised by adults.

Phase	Step	What Happens?
1	1	Each team constructs a tinker tree, trying to get the branches high enough to withstand surface fire but maximize the length of branch covered by newspaper.
	2	On the blackboard, the teacher records team names and total branch length of each tinker tree (length of branch covered by newspaper strips--may be part or all of a branch). In front of the class, the teacher underburns each team's entry by lighting two corners on one of the "long" edges of the newspaper. (See illustration for Activity IV-1. If the tree's foliage burns, the entry is erased from the board.
	3	The entries that "survive" underburning are compared. **The entry with the greatest total branch length wins Phase 1.**
	4	The teacher awards **Tinker Tree Derby Champion** badges to the winning team.
2	1	Each team that had a surviving tinker tree reclaims it and replaces the two-layer, newspaper "surface fuels."
	2	The team makes two "tinker saplings" by crumpling two half-pages of newspaper and using them to form two cone shapes about 5 cm tall. They place the tinker saplings under the branches, on each side of the tree trunk.
	3	The teacher underburns each tinker tree. **The tree that survives this fire, with "ladder fuels" in place, and has the greatest length of leafy branches, wins the grand championship.**
	4	The teacher awards **Tinker Tree Derby Grand Champion** rosettes to the winning team.

Specific procedures for the competition are written into the student handout (p. Vis-22).

Closure: Ask students to study the table describing tree traits related to fire resistance (Vis-23). Have them think about ranking the trees and perhaps make a preliminary ranking. Then, using the transparency of the same table, develop two class rankings--one for how resistant the mature trees are to fire damage, the other for how well the trees come back ("regenerate") after fire. For information, have students look again at the specimens used in **Mystery Trees (Activity III-2),** review information learned in this set of activities, and--if you want--read the essays in *Fire*

Ecology of the Forest Habitat Types of Northern Idaho (in the *FireWorks* Library), pp. 10-18.

AN ALTERNATIVE TO THIS CLOSURE--MORE FUN, BUT REQUIRING AT LEAST 40 MINUTES OF CLASS TIME: Try "Designer Trees," described below.

Integration & Closure Activity for Topic IV
Designer Trees
(optional)

What's the Point? **Tough Trees** is the longest, most complex unit in *FireWorks*. This optional activity is included to help students review and apply ideas covered in the topic. ***Designer Trees*** challenges students to design a tree that is well suited to a particular environment. Since the activity constrains students to work within a hypothetical "budget," it also introduces them to the concept that tree growth and forest development may be limited by the resources available.

You will need about 40 minutes of classroom time plus the following*:*

In this trunk	***You must supply***
Place Cards (6/set)	large paper for drawing
"sun dollars" play money	pencils and markers for drawing
Resource Bank sign	masking tape
Tree Trait Store sign	copies of handout Vis-24 for students
Tree Store Price List	
2 sets of Tree Trait cards (42/set)	

Procedures:

1. Select a Resource Banker. This person hangs the Resource Bank sign from his or her desk and sets up piles of sun dollars for distribution.
2. Select a Tree Trait Store Manager. This person hangs the Tree Trait Store sign from his or her desk, hang the Price List where it will be easy for students to see, and set up Tree Trait cards for sale. He or she should obtain about $5,000 from the Banker for change, mostly in $100s. The Banker and Store Manager can be the same person.
3. Designate 6 to 12 teams of students as Tree Designers. For 6 teams, use only one set of Place Cards and Tree Trait cards. For 7 to 12 teams, use two sets.
4. Shuffle the Place Cards and place them upside-down on a desk.

STEPS 5-11 ARE ALSO STATED ON THE STUDENT RULES SHEET, p. Vis-24.

5. Each Tree Designer team draws a Place Card. The card describes the location that this team will design a tree for. The location may be at a low or high elevation, it may have infrequent or frequent fires, and it may have poor or rich soil. Some locations have more resources available for plants than others. The Place Card states how many "sun dollars" the team can get at the Resource Bank for this location.
6. Each Tree Designer team visits the Bank and obtains the money that their Place Card entitles them to.
7. Each team plans how to use sun dollars to buy Tree Traits that will enable a tree living at their special location to survive fire, reproduce well after fire, or both. Any time, as students plan their budget or after it is complete, they can visit the Tree Store to buy Trait Cards.

8. A team can return any Trait Card to the bank for a refund.

MATH INTEGRATION: Have the Banker charge a service fee--a fixed price of $25, or 10% of the original purchase price--for any Trait Card returned.

9. Teams can trade and buy Trait Cards from each other. They can bargain over prices.
10. When a team has finished buying and bargaining for Traits, they draw a diagram of their Designer Tree on their special site. On the diagram, they include all information on the Place Card and label every Tree Trait.

Closure:

When all diagrams are completed, each team presents and explains its Designer Tree to the class. The class uses the handout on p. Vis-24 to decide what real species this Designer Tree most resembles.

List of Place Cards (1 set contains one of each):

Site	Fire Pattern	Worth in Sun Dollars
Low elevation, long growing season Ordinary soil	Fires occur every 5 to 30 years. They often have low flames.	$900
Low elevation, long growing season Soil full of gravel, poor for growing trees	Fires occur every 5 to 30 years. They often have low flames.	$800
Low elevation, long growing season Soil rich in ash from ancient volcano, good for growing things	Fires occur every 5 to 30 years. They often have low flames.	$1,000
High elevation, short growing season Ordinary soil	Fires occur every 50 to 100 years. They often have very high flames.	$700
High elevation, short growing season Soil full of gravel, poor for growing trees	Fires occur every 50 to 100 years. They often have very high flames.	$600
High elevation, short growing season Soil rich in ash from ancient volcano, good for growing things	Fires occur every 50 to 100 years. They often have very high flames.	$800

List of Trait Cards (1 set contains 6 of each):

Trait	Cost in Sun Dollars	Number Cards per Set
Basic tree: roots, trunk, leaves	$300	6
Bark (purchase by the centimeter of thickness)	$25/cm	20
Extra thick buds	$100	3
Serotinous cones	$200	2
Extra fast-growing trunk and branches	$100	2
Produces seed and cones at a very young age	$100	2
Loses low branches easily but still grows well	$100	2

Extension and Enrichment

1. Ask students to study ways in which other plants and animals survive fire in the *FireWorks Notebook* (in the *FireWorks* Library). Then use this information in a Survival Bee (similar to a spelling bee), where you name the plant or animal and the student describes how it copes with fire.

2. Ask the class to list environmental stresses other than fire. You may want to refer to Brian Capon's *Plant Survival* in the *FireWorks* Library. Environmental stresses might include flood, drought, very cold and very hot environments, and locations with very short growing seasons. Biological stresses might include epidemics of leaf- or cambium-eating insects, fungi that weaken stems or roots, and parasites that weaken or deform the tree. Ask each student (or team of students) to select one kind of stress, learn about it in reference books, and describe to the class:
   - what the stress is
   - how the plant or animal can survive or reproduce in that kind of stress
   - how the stress might benefit the ecosystem

3. Ask individual students to compare the ways in which plants cope with the heat of fire to the ways they cope with long-term heat in a desert environment. Use pp. 78-98 in Brian Capon's *Plant Survival* (in the *FireWorks* Library).

4. Ask an individual or a team of students to report on special adaptations of plant roots for coping with environmental stress, including fire. Use the *FireWorks Notebook* and pp. 15-17 in Brian Capon's *Plant Survival.*

5. Use materials and exercises from your textbook that describe the theory of evolution.

Topic V. Tree Stories

Reading Forest History from Cross Sections of Fire-scarred Trees

For Grades 6-9

Adapted from *Getting to Know Wildland Fire*

Basic Concept: People can learn about the history of a forest - and their own history - from looking at tree cross-sections. In this investigation, students use fire-scarred "tree cookies" to describe the fire history of three kinds of forest - ponderosa pine, lodgepole pine, and whitebark pine. Events in their personal history and in world history can be linked with events in the forest.

Background: Read p. 21 in Brian Capon's *Plant Survival* (in the *FireWorks Library*) for a good description of how tree rings are formed.

Subjects: Ecology
History
Mathematics

Objectives: 1. To increase student skills in
- observing
- recording data
- describing data mathematically
- working in teams
- communicating observations
- finding connections between ideas
- working in teams

2. To increase student understanding
- that forests have a history, just as humans do
- that fire is an important part of the history of most forests in the northern Rocky Mountains and the Intermountain area
- that forest history is often intertwined with human history

This topic has two activities:

1. ***Tree History,*** figuring out the fire history of a scarred tree
2. ***Forest Stories: Repeating Themselves?*** comparing fire stories from different kinds of forest

Extension and enrichment activities

Activity V-1.
Tree History

What's the Point? Tree rings and scars on trees tell the history of a forest. Fire has been a part of the history of most forests in the northern Rocky Mountains and the Intermountain area for thousands of years.

You will need about 20 minutes of class time and the following:

In this trunk	***You must supply***
Ancient Tree poster	small sticky-notes (20-30)
Demonstration cookie	dissecting microscope (optional)
tree cookies (10 or more)	***Tree Story*** data sheet for each student or team (p. Vis-25-26)
hand lenses (10)	calculators
straight pins (10+)	

Preparation: Find the "Demonstration cookie," a cross-section of a Douglas-fir tree that has very wide growth rings and no fire scars. Students can work in pairs or threesomes for this activity. Select the fire-scarred tree cookies to be used by your students. The *FireWorks* trunk contains ten cookies that most students can work with (not without some frustration). If you do not plan to use most of these, be sure to use at least three from ponderosa pine/Douglas-fir forest and three from lodgepole pine or whitebark pine forest. The species name is written on the bottom of each tree cookie. *FireWorks* also contains an extra cookie, designated "challenge" on the bottom side. You can use it as an illustration of the complexity of tree history, or not use it at all, or assign it to students who will be able to handle its ambiguity and difficulty. Set up dissecting microscopes for student use **if** you think they will be helpful and **if** your scopes are built so tree cookies can be set on their platforms.

Procedures:

1. Pass around the ***Ancient Tree*** poster. With the students, examine its fire scars and examine the growth rings on the "Demonstration Cookie," which has no scars. Pass the Demonstration Cookie around the class.
2. Explain fire scars to the students:

SPARK OF INFO: A fire scar is formed when part of a tree's cambium is burned or killed by heat. If the cambium is damaged only part-way around, the tree can continue to live. In the years after the fire, new wood forms at the edge of the damaged area. Year after year, new rings are formed that gradually curl over the edges of the damaged area and begin to cover it. From the outside, the scar looks like a black, triangular wound coming up from the ground. If the tree lives a long time without more fire damage, new wood from both sides of the scar may eventually cover the scar completely. We call these "hidden scars"; they are hidden from view but give the tree trunk a caved-in look on the scarred side.

3. Distribute fire-scarred tree cookies, hand lenses, and *Tree Stories* data sheets (p. Vis-25-26) to individuals or teams of students. Distribute calculators.
4. Ask students to examine their tree cookies. Point out the following:
   - Trees are not always killed when a cross section is taken. Many tree cookies are

obtained from dead standing trees and from stumps. A partial cookie can be collected by cutting through only a small section of the tree trunk. Pines are damaged little by this procedure.

- Historians recognize two important sources of fire prior to European American settlement of North America: lightning and Native American burning. Native Americans burned forests and grasslands for many reasons, including to improve forage and to increase safety (both from wildfire and from attackers). The relative importance of these two sources of ignition is hard to figure out.
- On the polished surface of a tree cookie, a fire scar occurs where young wood has curled over older wood at one or both edges of a damaged (often blackened) area. On the blackened front of a tree cookie, the same fire scar looks like a vertical fold in the wood.

5. Review the concept of an average and how to calculate it. Students will need this skill for question 2c on the data sheet and also for Activity V-2.
6. Ask students to study their tree cookies and complete their data sheets.
7. **OPTIONAL:** Check results against information in the ***FireWorks Cookie Book*** (in the *Teacher Box*). This book contains a list of approximate fire intervals for each cookie.

Teacher's Notes for "Tree Stories" Data Sheet, keyed to questions on the sheet.

1. A hand lens will be essential for examining very narrow rings. If you are working in direct sunlight or near sunny windows, be alert for students trying to light fires with their magnifying glasses. It's almost irresistible, but it's not what the magnifiers are for in this case.

3b. Decreases in fire activity can be caused by moist time periods, increases by dry periods. Some forests show a decrease in fire during the 1800s, probably caused by the confinement of Native Americans to reservations. Earlier decreases may have been caused by the severe decline in Native American populations due to smallpox.

Very few trees have fire scars dating after 1920 or 1930. This is because successful programs excluding fire from forests and grasslands began in those years, and also because grazing of livestock reduced fine vegetation (fuels) such as grass and shrubs.

4c. Poor growth is likely to occur after fire if the fire killed many of the tree's needles or much of the cambium. Rapid growth after fire may be caused by decreased competition from other vegetation for moisture and nutrients or by an increase in nutrients from burned vegetation.

5. Answers to this question vary from place to place and from one tree species to another. In ponderosa pine/Douglas-fir forests of the northern Rocky Mountains and the Intermountain area, when fire is excluded from a forest for a long time, dense undergrowth develops. This understory makes fires very hazardous and likely to kill even large, old trees. Large trees can also be weakened by competition for moisture and nutrients when they are crowded by understory trees. Lodgepole pine forests have followed this pattern (long intervals between fires and severe burning) for thousands of years; lack of fire affects them mainly because the mosaic of forest patches across the landscape becomes more uniform.

Closure/Transition: Proceed right to Activity V-2.

Activity V-2.
Forest Stories: Repeating Themselves?

What's the Point? The pattern of fire history for a particular kind of forest is sometimes called its "fire regime." The fire regime describes how often fire usually occurs and how severe it usually is. Ponderosa pine/Douglas-fir forests were, in past centuries, caracterized by frequent surface fire (usually averaging every 5 to 30 years). Both lodgepole pine/subalpine fir and whitebark pine/subalpine fir forests had less frequent fires-- approximately every 50 to 100 years. Some of these fires were surface fires, but many-- especially in lodgepole pine-- were severe, often crown fires.

In this activity, the class works together to compare the frequency of surface fire in historic ponderosa pine/Douglas-fir forests with that in lodgepole pine and whitebark pine/subalpine fir forests. This brief activity synthesizes information from Activity V-1, *Tree Stories.*

You will need about 20 minutes of classroom time plus these materials:

In this trunk.	***You must supply***
Forest Stories transparency (p. Vis-27)	washable transparency pens
	overhead projector

Students will also need their *Tree Story* data sheets and calculators from Activity V-1.

Procedures:

1. Ask each team of students to enter its **average interval between fires** (data sheet, #2c) in the appropriate column of the transparency.
2. Ask students to compute the average fire-free interval for the *kind* of forest represented by each column (ponderosa pine, lodgepole pine or whitebark pine).
   Ask students to interpret this data summary. Interesting lead questions:
   a. Just how different are these averages? Do they just represent variation from one location to another, or do they represent real differences between kinds of forests?

MATHEMATICS INTEGRATION: Research scientists try to answer this kind of question using statistics. The sample size here is very small, so statistical testing is not completely appropriate. However, students could try statistical tests such as the group t-test and the Mann-Whitney U test on these data.

   b. Why might the fire-free intervals seem different in different kinds of forest? (Both lightning incidence and Native American uses differed greatly in different kinds of forest. Native American use probably depended a lot on the season of the year.)
   c. Could the answer to question 5 in Activity V-1 (can trees be damaged by ***lack*** of fire?) differ from one kind of forest to another?

Closure: Eventually, we plan to have a short videotape showing interviews with scientists who work in these three forest communities, in which they describe their thoughts about the effects of changing the fire regime.

Sparks of Information: Here is what some scientists think about this question.

ABOUT PONDEROSA PINE-DOUGLAS-FIR FORESTS: Many scientists think that some areas with ponderosa pine and Douglas-fir forest should be thinned to remove some of the thickets of small trees. They also recommend burning these forests after thinning to reduce the number of saplings and the amount of fuel on the ground. (Burning in this way is a job only for trained professionals.) These actions, scientists believe, will make more water and nutrients available to large, old trees and will reduce the likelihood of severe fire. During the past 10,000 years, frequent underburns apparently occurred in most ponderosa pine forests.

ABOUT LODGEPOLE PINE-SUBALPINE FIR FORESTS: Fire history studies show that these forests may grow for a century or more without fire and then burn in a large, severe fire. Sometimes they underburn once or twice in between. Many scientists think that lodgepole pine-subalpine fir forests are gradually becoming more uniform without fire. This means less habitat variety and increasing risk of large fire.

ABOUT WHITEBARK PINE-SUBALPINE FIR: Scientists are very worried about these high-elevation forests because most whitebark pines (more than 95 percent in Idaho) have been killed by a non-native disease, white pine blister rust. (This complicated pattern is investigated in ***Topic VI.***) A few whitebark pines survive the rust, so scientists think their seeds should have the best possible chance to grow. Burned areas may provide the best growing conditions for them.

Extension and Enrichment

1. TIME LINE. On a flipchart page, write the dates of fires recorded on the *Ancient Tree* poster. Ask students to identify dates in human history and label them on the time line. Draw pictures to illustrate some of these events. Below is a list of some dates from American and European history that may help students link forest history to human history.

YEAR	EVENT
1910	Glacier National Park created
Nov. 8, 1889	Montana becomes 41st state
July 3, 1890	Idaho becomes 43rd state
1849	Gold discovered in California
1805	Lewis and Clark expedition
1776	Declaration of Independence signed
1734	Daniel Boone born
1620	Pilgrims land at Plymouth Rock
1595-1617	Pocahontas's lifetime
1564	Shakespeare born
1519	Magellan begins voyage around the world
1508	Michelangelo starts painting Sistine Chapel
1492	Columbus lands in Americas
1446	Gutenberg uses printing press
1348	Black Death (bubonic plague) kills 1/3 of Europe's population

2. Ask students to learn the birth years of family members, particularly their own and those of their grandparents and great-grandparents, and include them in the time line in #1.

Topic VI. Enlarging the Picture

Forest Residents and Changes through Time
for Grades 6-9

Basic Concepts: Students studying *FireWorks* have been investigating wildland fires and their effects on trees. To look at fires' effects on a whole forest community and ecosystem, you have to look at a much bigger picture: all the forest inhabitants (including plants, mammals, insects, fungi... their nonliving environment, and their interactions through time). Those ideas are explored in this topic.

Always Changing is a drama that students produce, based on research they do (using *FireWorks* materials) regarding forest inhabitants and change through time--**succession**. **IF YOU ARE CONCERNED** that students do not have sufficient background yet, in plant and animal adaptations to fire, check out "Buried Treasures" and "Run or Hide!" in *FireWorks for Grades 1-5*, pp. E-36-37 and E-40. *Puzzling It Out* is a quiet activity for individuals or small teams of students, in which they use their understanding of forest communities to solve interrelated jigsaw puzzles.

Background:

1. *National Geographic* article "The Essential Element of Fire" by Michael Parfit, pages 116 through 139 in the September 1996 issue, Vol. 190 (3). In the *FireWorks Library*

2. Jack deGolia's book *Fire - a Force of Nature* (in the *FireWorks Library*) describes the main concepts of forest succession. See pages 30-31.

3. "Cycles Behind the Scenes," pp. 15-17 in *Getting to Know Wildland Fire* and pp. 43-45 in the *Fire in Florida's Ecosystems* Educator's Guide (both in the *FireWorks Library*) provide enriching information on succession and other cycles.

4. Read Chapters 5, 6, and 10 of Ronald Lanner's *Made for Each Other* (in the *FireWorks Library*). These chapters describe the cones and seeds of whitebark pine (and related pines), the Clark's nutcracker's habit of planting whitebark pine seeds, and how pine squirrels and grizzly bears use whitebark pine.

5. "Phoenix Rising," reprinted from the Spring 1996 *Montanan*.

6. Read the discussion of succession (independent of fire) on pp. 73-75 in Brian Capon's *Plant Succession.*

Subjects: Biology

Ecology
Language
Speech/drama
Art (optional)

Objectives:

1. To increase student skills in
   - researching technical information
   - communicating technical information
   - working together to prepare and give a presentation

2. To increase student understanding
   - that a forest has many kinds of plants and animals, which influence one another
   - that a forest changes constantly through time
   - that native plants and animals have ways to survive fire or reproduce after fire, or both

This topic has two activities:

1. ***Always Changing,*** researching, writing and presenting a dramatization of forest succession
2. ***Puzzling It Out***, a set of jigsaw puzzles that can be solved only with knowledge gained from **Topics I-V** and **VI-1.**

Extension and Enrichment activities

Activity VI-1.
Always Changing

Basic Concept: Forests change over time. Different kinds of plants and animals have different needs. Some grow well only in sunny openings; some grow well almost anywhere as long as they can get water. The forest architecture and the species composition of a forest change over time, a process called "succession." But many things interrupt succession. A forest is a tremendous storeroom of carbon, which forest residents use for their own needs. Fungi consume wood (both living and dead) and roots. Insects feed on needles, tree cambium, and dead wood. Small mammals and birds eat seeds. Just as the forest is constantly changing, its carbon is constantly being reused and recycled. Fire is the most dramatic recycler.

This *FireWorks* activity asks students to work on three teams (one for each forest type we've been studying). The teams use information in the *FireWorks Library* to present a play showing 100 years of change in forests of the northern Rocky Mountains and the Intermountain area.

INTERESTED IN ALTERNATIVES? You can cover the information in this activity in several other ways: For a quiet, clear approach, have small groups of students prepare and present the three feltboard stories for the three forest communities. (Materials are in the feltboard kits for ponderosa pine, lodgepole pine, and whitebark pine.) For an approach similar to this activity, but requiring less student initiative, use *Drama in the Forest*, pp. E-47-48 in *FireWorks for Grades 1-5.*

You will need at least 45 minutes of classroom time for plays, in addition to time for student research and preparation, plus the following:

In this trunk	***You must supply***
Pathways in Time notebooks (3)	art supplies for masks or puppet shows
FireWorks Notebook	copies of handouts Vis-28-30 for student teams
Feltboard kits for ponderosa pine, lodgepole pine, whitebark pine	string and scissors if you plan to do the BIOLOGY AND PHYSICAL SCIENCE INTEGRATION activity at closure

Preparation: The product from this activity can take one of three forms: a play or puppet show (written and produced by the students), or a storytelling session, in which students use the feltboard materials in the *FireWorks* trunk. Directions here and in the student handouts are for a play, in which students depict forest inhabitants using masks; in the play, they are interviewed by a TV reporter about changes that have occurred in the past century. You can change the assignment to producing a puppet show, if you prefer that format. A narrator could be used in place of a TV interviewer. You can also change the assignment-- perhaps reducing the time required-- by instructing students to use the feltboard kits from this trunk (for Ponderosa Pine, Lodgepole Pine, and Whitebark Pine) to depict how their forests change over time instead of writing and presenting a play.

Use the handouts on pp. Vis-36-37 for planning. Ask each student to adopt an organism on this list. (Each organism is described in a two-page essay in the *FireWorks Notebook.* The essays are removable from this notebook, so students can "borrow" them while they study and prepare.)

Procedures:

1. Post the assignment list in the classroom so students can refer to it in planning.
2. Explain: Students will work in teams to present a drama that describes three kinds of forest (ponderosa pine, lodgepole pine, whitebark pine). Each team will present a play showing how this kind of forest looks and works now, what it was like right after a fire 100 years ago, and what it was like in about 1950. The play should be no more than 15 minutes long.
3. Ask the three students depicting the three pine species to be "directors" of the three productions. Give each director a copy of the handout for his or her forest community (pp. Vis-28-30), and ask them to use the assignment list to fill out this cast of characters.
4. Give each director the *Pathways in Time* booklet for his or her forest community and the feltboard kit for that community. The narrative for the feltboard describes the relationship of that community to fire. Students can construct the feltboard, following the directions in the kit; or simply read the narrative for information.
5. Give each character the pages from the *FireWorks Notebook* for his or her organism. Many characters will appear in only one drama, but others (elk, American marten, red-backed vole, and subalpine fir) will occur in more than one. Explain that these "shared" organisms must work with each team that provides habitat for them.
6. Give each team art materials for making masks, costumes, puppets, etc.
7. Have students plan their plays, research their plants and animals, write and rehearse.

Closure:

Have students produce their plays for one another and, if possible, for other classes.

Activity VI-2.
Puzzling It Out

Basic Concept: Discovering how the inhabitants of a forest interact is a little like assembling a very complicated jigsaw puzzle. In this activity, students use what they have learned about fire, plants, animals, and succession to assemble jigsaw puzzles about ponderosa, lodgepole, and whitebark pine forests. They have to use information about many species and distinguish three different kinds of forest to complete the puzzles.

You will need about 15 minutes of classroom time plus the following:

In this trunk

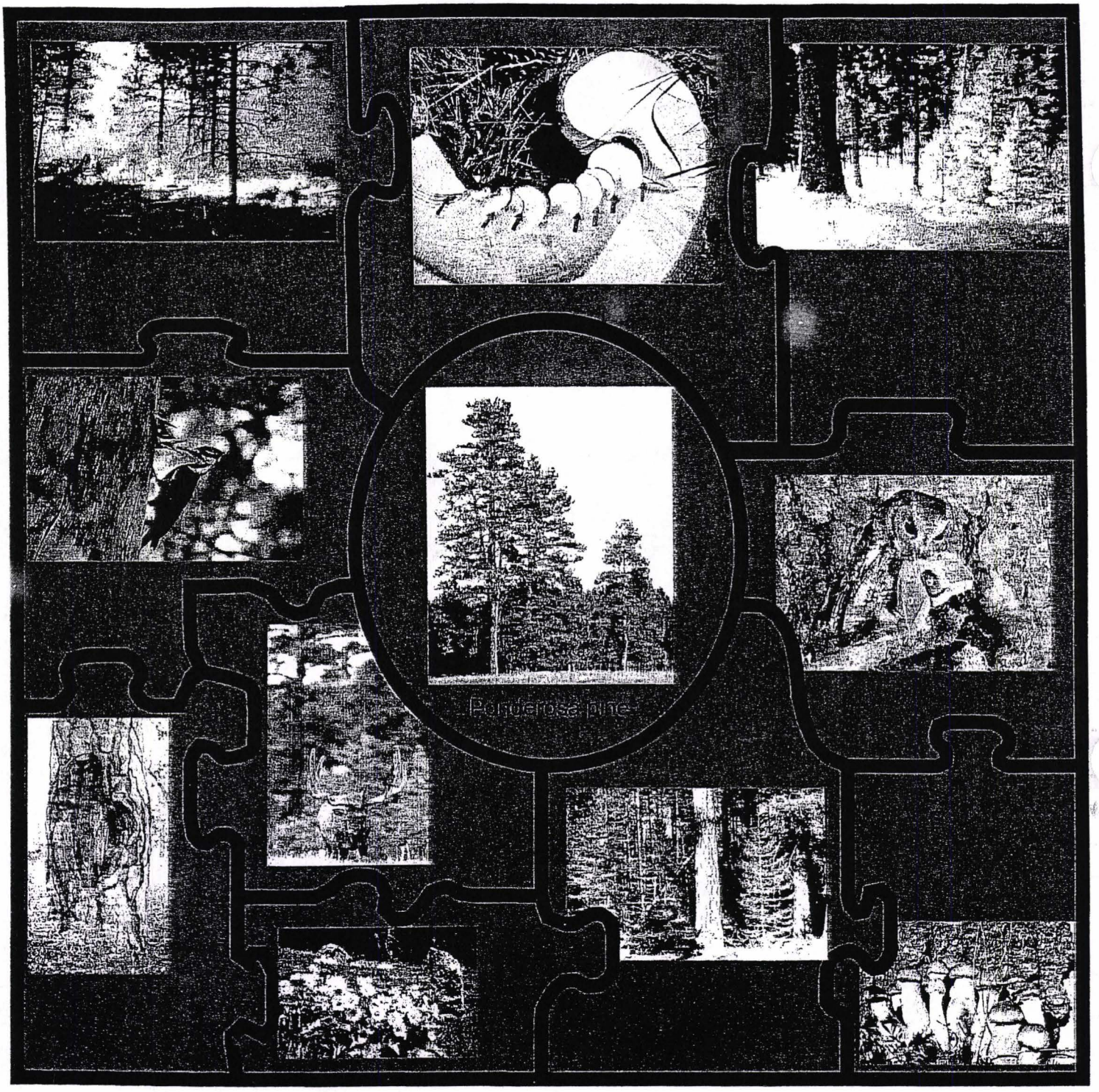
Forest Puzzles envelopes (4)

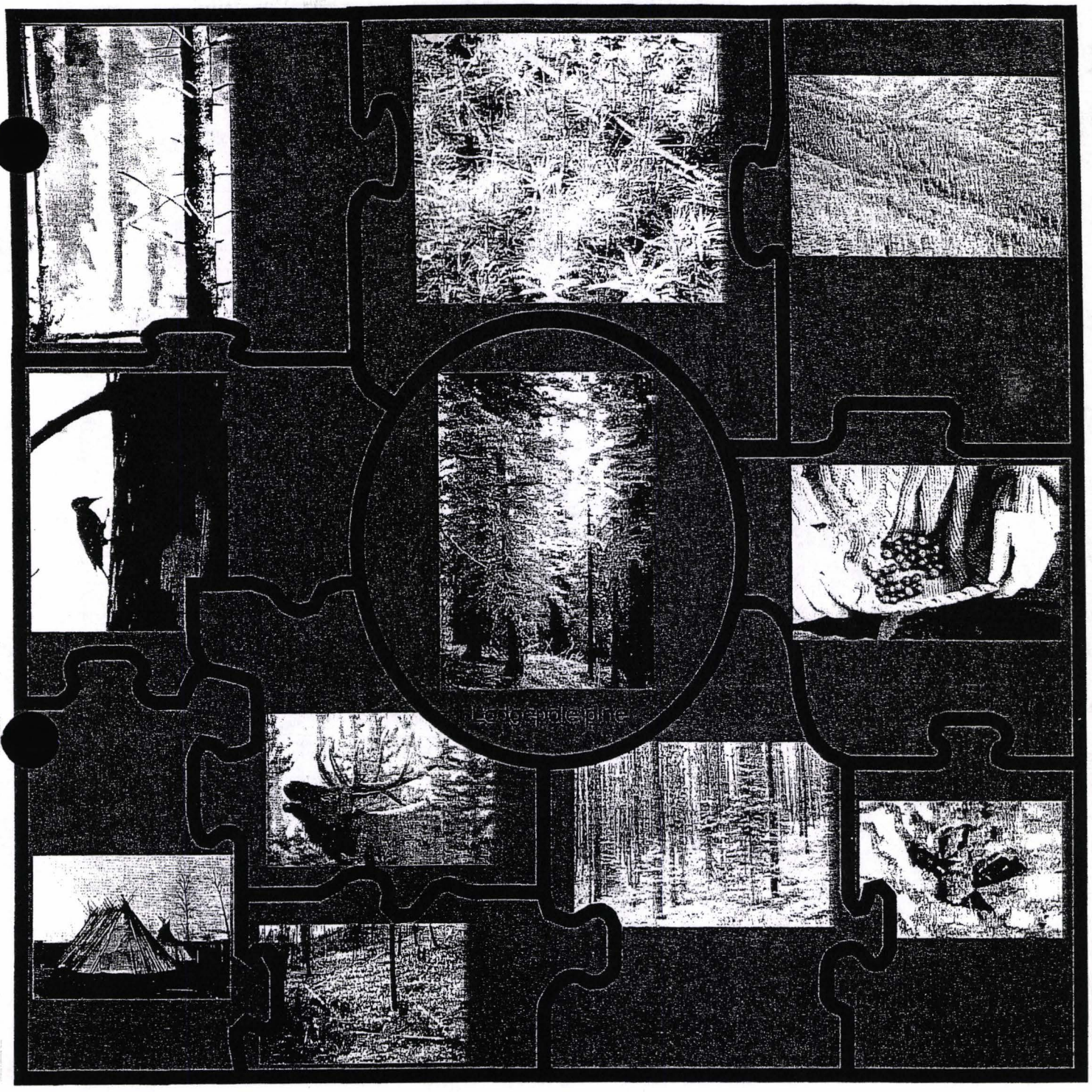
Procedure:

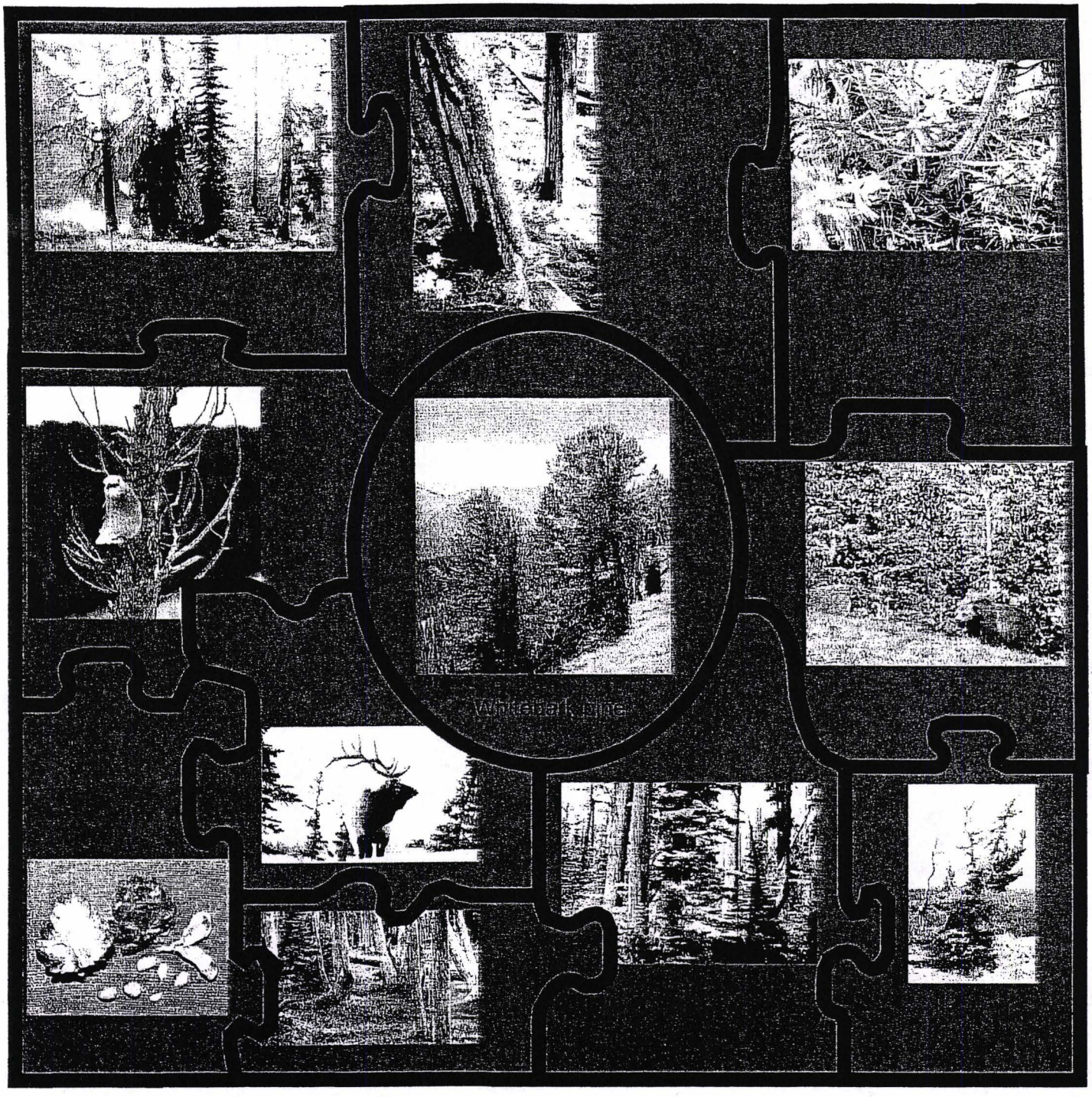
In this activity, students work in teams. *FireWorks* contains enough materials for four teams to work simultaneously. Each team uses one envelope of puzzle pieces to assemble three puzzles simultaneously: one about ponderosa pine forests, one about lodgepole pine, and one about whitebark pine.

1. Explain that each *Forest Puzzles* envelope contains the pieces for **three** 11-piece jigsaw puzzles. All three puzzles are cut on the same pattern.
   - All have a picture of a pine tree in the center - ponderosa, whitebark, or lodgepole pine. (If students need to review the kinds of trees, have them review the materials studied in *Mystery Trees*, Activity III-2.)
   - Across the top, all puzzles show typical fires and change in that kind of forest over time.
   - Across the bottom, all puzzles have photos and information about other plants and animals that live in that kind of forest and how they interact with one another.
3. Explain: Since the puzzles are all cut from the same pattern, many pieces are interchangeable. To assemble them correctly, students will need to use what they already know, look closely at the pieces for clues, and use new information written on the puzzle pieces.
4. OPTIONAL: Review these key concepts that students will need to know:
   - Ponderosa pines grow best at low elevations, on dry sites. In the past, most fires here were surface fires and did not kill the large trees. Trees could grow very old and very big.
   - Whitebark pines grow best at high elevations, on dry sites. In the past, some fires were surface fires and some were crown fires.
   - Lodgepole pines grow well at middle elevations. They do not get very old or very large. Fires are not frequent, but they often crown and kill most of the trees.
5. If you want students to have some guidance in solving the puzzles, hand out the ***Puzzle Strategy*** suggestions on p. Vis-31.

Closure: When students report that they have completed the puzzles, check it against the puzzle-master illustrations here.


Ponderosa pine


Lodgepole pine


Whitebark pine

Extension and Enrichment

1. *In the Web*, pp. 46-48 in *FireWorks for Grades 1-5*, provides an entertaining activity that uses the same organisms and masks or costumes used in *Always Changing* to depict the interrelationships of energy and shelter that make these forest ecosystems work.

2. On a field trip, use the activity **"Observe a Rotten Log or Stump,"** p. 25 in *Investigating Your Environment* (in the *Teacher Box*). This set of materials was produced by the U.S.D.A. Forest Service.

3. On a field trip, use the activity **Communicate Through Sketching and Writing,** p. 29 in *Investigating Your Environment* (in the *Teacher Box*).

4. Read pp. 87-127 in *Yellowstone Aflame*, a photojournalists' description of the 1988 fires in Yellowstone National Park.

5. Have students make flip books[1] to illustrate succession in a ponderosa pine, lodgepole pine, or whitebark pine forest.

6. Draw a series of pictures showing some of the ways in which an old, decaying ponderosa pine provides resources for the forest. Here are some possibilities. If the descriptions below mention a plant or animal that you don't know about, look it up in the *FireWorks Notebook* or other resources in the *FireWorks Library*.
   - While still alive, the ancient pine tree can provide a nest site for pileated woodpeckers, then for bluebirds or owls. Different kinds of fungi can live in its wood; some grow like shelves outside the bark. Under the tree's bark, western pine beetles may feed on the cambium. Ponderosa pine mistletoe may live in its branches, providing food and hiding cover for small birds.
   - If the tree dies but remains standing, it can still be used for nests. With the branches bare, it also provides a hunting perch for hawks and large

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[1]Thanks to *Fire in Florida's Ecosystems* Educator's Guide (p. 43) for this activity.

owls. Under its dead bark, beetles thrive. Ants build multi-storied cities in the dead wood. Where the bark peels loose, brown creepers nest behind its flakes.

- When the tree finally falls, pine squirrels may nest inside its hollow trunk. Mice and voles travel along the ground at its side, where they are partly hidden from predators. Not easily fooled, pine martens raise their young nearby so they can feed on the mice and voles. Fungi gain nutrition from the dead wood. Worms and many-legged creatures eat the decaying wood; their feces enrich the soil. The dead tree blocks rocks, leaves, and soil that roll downhill, so a tiny, rich garden may form on the uphill side.
- Even after the tree is mostly broken down, when it only looks like a long trail of wood flakes along the ground, thousands of pieces of its wood lie within the soil. The pieces keep the soil from being packed down by rain and animals travelling above. Constantly under attack by more fungi, worms, and arthropods, these pieces of wood are a continuing source of nutrients for living things in the soil and above it.

Topic VII. Dealing with Fire

Basic Concept: **Topics I-VI** show that fire is quite at home in the forests of the northern Rocky Mountains and the Intermountain area, and also that the plants and animals of these forests are quite at home with fire. The people who lived or travelled in these forests prior to 1800 were also at home with forest fire, often using it for their own purposes. Native American used fire to make their campgrounds safe from fire and enemies, and to improve grazing for the wild animals that they hunted. Things have changed since those times. People have built permanent homes in the midst of forests or along their edges. Tens of thousands of people live in valleys that may be filled with smoke during forest fires. People all over the world use materials made from trees that may be killed by fire.

In this topic, students learn about some of the people who work with fire. Then they become decision makers, judging situations and applying what they know about wildland fire. Finally, they can revisit their relationships with forest fire by responding again to ***Visiting Wildland Fire***, the slide-tape show used in **Topic I**.

Background:

1. Read pages 35 through 45 in Patrick Cone's *Wildfire* (in the *FireWorks Library*) for information about the professional forest workers who fight fires and sometimes start fires for specific purposes. *Wildfire* has many excellent color photographs and diagrams.

2. Read p. 13, "Evaluation of Wildland Fires," in the *Teacher Background Information* booklet in *Fire Ecology*, Resource Management Educational Initiative from the Ecological Communications Laboratory at Ohio State University (in the *Teacher Box*). In the same curriculum, read "Fire in My Backyard" and "Fire Feelings," p. 1.

Subjects: Social science
Language Arts
Mathematics
Ecology
Physical Science

Objectives:

1. To increase student skills in
   - using new information to solve problems
   - making decisions based on scientific knowledge and human values
   - identifying and describing feelings

2. To increase student understanding
   - that fire research and management are skilled technical professions
   - that fire affects nearly everyone in the northern Rocky Mountains and

the Intermountain area

- that people living near forests can do many things to increase fire safety
- that people's feelings may or may not change after they learn new information

This topic has two activities:

1. ***You Decide!*** a planning project for a specific area of forest.
2. ***Revisiting Wildland Fire***, a return to the slide-tape show that introduced *FireWorks* in Topic I.

Extension and Enrichment

Activity VII-1.
You Decide!

What's the Point? Students take on the responsibilities of forest owners and managers. First, they view a slide show about smoke and some short videotape segments to learn a little about **fire management**. Then they "go to work." Student teams are assigned a plot of land with some information about the "neighborhood," the land's fire history, and what it is like right now. Then they set goals for the land and develop a 10-year plan for managing it. They balance concerns about safety, esthetics, animal habitat, and expenses as they make plans for their land.

You will need at least 15 minutes of class time for the background (slides, videotape, and explanation of the assignment), then approximately 10 minutes per student presentation at the end of the project, plus the following:

In this trunk	*You must supply*
Fire and Wildlife videotape	VCR and monitor
You Decide! brochures from the *Teacher Box*, one for each student team	calculators
Pathways in Time booklets from the *FireWorks Library*	
FireWorks Notebook from *FireWorks Library*	
Feltboard kits	

Preparation:

1. Find the three videotape cues. We suggest showing at least #2 and #3. The table below tells you where to find the three clips you may want to show in class. It lists the number of minutes into the video when the clip starts ("cue time") and the time into the video when the clip ends ("stop cue"). Stop the tape right after the "audio before cue" to have it ready to show the class.

clip	subject	cue time (min)	audio before cue	length (min)	audio at end of clip	stop cue (min)
1	history of fire management	3:58	"...which last excessively bad and thickly strewed with falling timber and pine."	4:47	"We have failed to make any use of fire in our forestry except in slash disposal."	8:45
2	professional work of prescribing fire	27:27	"... opens wildlands to easy access by the motorized public."	2:50	"In many instances, the amount and quality of forage can be dramatically improved with the proper use of fire."	30:18
3	continued need to suppress fires and need to prescribe some fire	36:15	"...demand that we continue to learn and grow in the relationship."	5:15	"... the positive link between a healthy habitat and fire cannot be ignored."	41:30

2. Plan how to assign projects to students. There are five "management challenges" available:
   1. Home in the Pines (ponderosa pine, wildland/urban interface)
   2. Cabin in the Woods (lodgepole pine, remote area)
   3. Questions in the High Mountains (whitebark pine, public land)
   4. Burnt Trees: a Gift (lodgepole pine stand recently killed by crown fire)
   5. Caretaker of the Ancient Forest (ponderosa pine old growth in urban area)

   You may want to have teams of students work on only two or three of the management challenges, or you may want to have at least one team work on each. You may want to assign two groups of students to each management challenge (sharing materials), then schedule the two teams' presentations together. This would show the class how different management plans can arise from different objectives.

Procedures:

1. Explain: Students will plan how to take care of a forested area. They will set goals for their

land and prepare a "management plan." Sometimes land owners and managers use fire on purpose to change the architecture of a forest or improve its habitat quality for a particular species. In preparation for forming their own management plans, students will learn a little about smoke and professional use of fire. Students may need their notes on these subjects for planning.

2. Explain: Some property owners and land managers use fire on purpose to change the forest architecture or habitat quality. These video clips show a little bit about management use of fire. Students may need this information as they develop their management plans.
3. Show the video clips.
4. Explain the assignment: Each team of students is responsible for taking care of a forested area for the next ten years. Some of the areas are private land, and students will be the "owners." Other areas are public land, and students will be the "managers." Their assigned land is described in the *You Decide!* brochure for each team.
5. Explain how much time students have to prepare, whether they will prepare in class or as homework, and what kind of final report you want (written and/or class presentation... even a presentation followed by a debate is possible).
6. Provide supplies and materials, including calculators, the *Pathways in Time* booklets, the feltboard kits, and other materials from the *FireWorks Library*.

MATH INTEGRATION: This would be an excellent project in which students could use a computer-based spreadsheet.

7. Schedule presentations. After each presentation, ask for student questions.

Closure:

Ask students about their process of setting goals and planning. Here are some leading questions:

1. Did you find it hard to agree on goals or on ways to reach those goals? Which process was more difficult-- setting goals or finding ways to meet them?
2. Did you find it difficult to work toward goals that you didn't agree with?
3. How easy is it in the "real world" to change goals for private land? (In a legal sense, it's very easy unless it interferes with laws for public protection. However, you may want to consult your neighbors, your attorney, and your insurance agent about any dramatic changes you envision.)
4. How easy is it to change goals for public land? (Usually this requires legislative change or directions from appointed officials. Research and public discussions are often required.)

Explain: For real land managers, safety is almost always the first, most important goal. They don't want visitors or workers getting hurt-- now or fifty years from now-- because of the way they manage the land. In a forested area where people live, it may be very difficult to keep the forest safe. The people who live there have to help by being careful with fire and by reducing fire hazards around their homes. In a place far from people's homes, managers can work toward other goals, like improving habitat quality or protecting plant species that depend on fire, while still providing for safety.

Activity VII-2.
Revisiting Wildland Fire

What's the Point? When the class began *FireWorks*, students viewed and responded to a slide-tape show with their thoughts and feelings about wildland fire (**Topic I**). Now they can respond to the same pictures and sounds again and consider whether their thoughts and feelings have changed in light of what they have learned.

You will need about 30 minutes of classroom time plus the following:

In this trunk	*You must supply*
Visiting Wildland Fire slide carousel	slide projector & screen
	student responses and flipchart completed in **Topic I**
	OPTIONAL: copies of student handout *What Do You Think?* (p. Vis-32)

Procedure:

1. Explain: This is the same slide show that students viewed at the start of *FireWorks*, containing photos of fire and burned areas. They can now look at their earlier responses and think about ways in which their thoughts may have changed (or not) after studying fire ecology.
2. Start the slide show. Advance the slides every 8-10 seconds.
3. Give students time to write or make a drawing that records their thoughts and feelings.
4. Hand out the students' first responses to *Visiting Wildland Fire* and post the flipchart from **Topic I** on the board. Ask students to compare their current thoughts and feelings with the ones recorded earlier. Use the following questions (if you wish to have students respond in writing, use p. Vis-32):
   - What feelings are the same?
   - What feelings are different?
   - Pick one feeling that has changed. Can you explain why? If no feelings have changed, can you explain why?

Closure: Ask students to compare the thoughts recorded on the two flipcharts and explain some of the differences. Ask what information (if any) led to changes in responses.

Extension and Enrichment

1. Use the lesson ***Ecosystem Management,*** p. 18 in *Branching Out to the Youth of America*, which is in the *Teacher Box*.

2. Ask a team of students to read and compare the two *National Geographic* articles on fire that are included in the *FireWorks Library*:
   - "The Great Yellowstone Fires" by David Jeffery, pages 252 to 273 in the February 1989 issue, Vol. 175 (2).
   - "The Essential Element of Fire" by Michael Parfit, pages 116 through 139 in the September 1996 issue, Vol. 190 (3).

3. Use the lesson *Reporting the Blazes* in the *Fire Ecology Resource Management Education Unit* (U.S. Department of the Interior curriculum) in the *Teacher Box*.

4. Fire suppression is one of several careers that arise from North America's complicated relationship with wildland fire. Jack deGolia's book *Fire - a Force of Nature* (in the *FireWorks Library*) describes the work and frustrations of firefighting (pp. 44-47).

5. Another interesting description of firefighting is in the photjournalists' description of the 1988 fires in Yellowstone National Park, *Yellowstone on Fire*, pp. 57-85.

Visual Aids and Handouts for *FireWorks*

Master Copies of

Transparencies and
Student Handouts
for Classroom Use

Draft 2-14-98

Fire Triangle

Name_____

1. What is fire?

2. Burnable things surround us every day. Why aren't they on fire?

3. What is the fuel in fires we are familiar with?

4. What fuels a forest fire?

5. Where does the oxygen for fire come from?

6. What heat sources do we use to start fires?

7. What provides heat for wildland fires?

8. How does wind influence fire?

9. Use the fire triangle to describe some ways to put out a fire.

Student Handout, Transparency

Fire Triangle Kit

1. Cut along the dashed lines to make the three "legs" of your Fire triangle.
2. Mark one leg "Fuel." Mark another "Oxygen." Mark another "Heat." You may decorate the pieces.
3. Punch holes on the X marks at the ends of each leg.
4. Put brads through the holes to connect the legs of the triangle. Write your name on the back.
5. If you remove one leg of the triangle, what happens to it?
6. If you remove one leg of the Fire Triangle, what happens to the fire?

-- -- -- -

Testing the Fire Triangle - Experiment 1.

Names

Organize your team. On a team of 4, one person should light matches and observe heat; one should measure time, one should measure flames, and one should record data. Change jobs if you repeat the experiment.

Procedures:

1. Place the burning tray on a heat-resistant surface. Set the support stand in the center of the burning tray. Attach the clamp near the top of the ring stand. Attach the rod with alligator clips at each end to the clamp, so it forms a "T" with the stand.
2. Clip a wooden match to each alligator clip. Clip one match in so it points straight up, with the ignitable tip at the top. Clip the other in so it points down, with the tip at the bottom.
3. Light a third match and use it to ignite the downward-pointing match. Record your observations in the first column below, lines 1 and 2.
4. Use another match to ignite the upward-pointing match. Record your observations in the second column below, lines 1 and 2.
5. Do the experiment with two fresh matches. Have one person on the team carefully place her or his hand above, below, and next to the flame to see if any areas are hot. Record observations in line 3 below, both columns.
6. Do the experiment again, if necessary, so you can answer the questions below.
7. Use the results of your experiments and what you have learned about the Fire Triangle to explain (line 4, both columns) why the matches go out.

	Match is pointing...	DOWN	UP
1.	Without putting the ruler in the flame, estimate how long the flame is (cm).		
2.	How long did the fire burn (seconds)?		
3.	What direction did most of the heat go?		
4.	Why do you think the match went out?		

Student Handout

Testing the Fire Triangle - Experiment 2.

Name_____

Organize your team. One person can light the candle. One can fill a beaker with water and pour it over the dry ice. Another can pour the CO_2 onto the candle flame. One should record observations. Change jobs if you repeat the experiment.

Procedures:

1. Place the candle on a paper towel. Fill one beaker with water.
2. Light the candle.
3. Ask the teacher to use tongs to place a small chunk of dry ice in the empty beaker. DON'T TOUCH THE DRY ICE-- it is cold enough to kill the top layers of your skin almost instantly.
4. Pour about 200 mL of water over the dry ice.
5. Answer question 1 below.
6. Gently tip the beaker with dry ice over the candle. Don't tip it so far that the water pours out.
7. Answer questions 2 and 3 below.

1. Describe what you observe when water is poured over the dry ice.	
2. Describe what you observe when you pour the "fog" from the dry ice beaker over the candle flame.	
3. What part of the fire triangle changed to cause what you observed? Explain.	

Student handout

The Fire Triangle in Wildlands

Names_____

In this demonstration, you watch fires on three slopes--flat, medium, and steep. Answer questions 1-3 using the demonstration fires as examples.		
1	How does the steepness of a hillside affect fire's rate of spread?	
2	How well do fires burn downhill?	
3	How does steepness affect the completeness of a crown fire (how many of the trees burn)?	
Now you will burn four more "matchstick forests" to explore how the arrangement of trees affects fire spread. Answer the questions below.		
	Describe matchstick forest	**How well did this arrangement resist crown fire?**
4		
5		
6		
7		
8. Which forest arrangement (4-7) was best and which was worst at resisting crown fire?		

Student Handout

Up in Smoke *Name(s)*_____

. How much smoke was produced in each matchstick fire?

	Weight of matches (g)		Weight burned (g)	X 0.004 g smoke /g burned	=	Amount of smoke (g)
	before fire	after fire				
a.				X .004	=	
b.				X .004	=	
c.				X .004	=	
d.				X .004	=	
e.				X .004	=	
f.				X .004	=	
g.				X .004	=	
h.				X .004	=	

. Which matchstick fire produced the most smoke? _____

3. Which produced the least smoke? _____

4. Describe how smoke production is related to amount of fuel burned.

_____

5. This table shows how much fuel burned in some fires. How much smoke was produced?

	Kind of Fire	Fuel Burned /Hectare (metric tons)	X kg Smoke /Ton Fuel Burned	=	Smoke per Hectare (kg)
a.	Ground - little duff	2.2	X 16.6	=	
	- lots of duff	30.7	X 16.6	=	
b.	Surface	22.0	X 8.6	=	
c.	Crown	36.1	X 9.3	=	

Student Handout or Transparency

Tree Parts Glossary

bark	the outside covering on a tree's trunk and branches, the tree's "skin"
branch	limb of a tree that grows out from the trunk.
broad-leaved	the kind of tree that has wide, flat leaves. Most broad-leaved trees in the northern Rocky Mountains and Intermountain area drop their leaves in the fall.
bud	starting point for next year's tree growth. Buds grow at the tip of each branch, at the top of the tree, and at the tips of roots. Buds have many living cells.
cambium	a very thin layer of living cells right under the tree's bark. This part of a tree's trunk and branches--and even under the surface of roots--carries water and nutrients between roots and leaves.
cell	the smallest living part of a plant that can make new living parts
cone	the "package" in which a conifer stores its seeds
conifer	the kind of tree that stores its seeds in cones
crown	a tree's top, where most of the buds and leaves are
deciduous	able to shed its leaves in the fall or when it becomes very dry
duff	the top layer of soil in a forest. Duff is made up of dead, rotting plant parts.
leaf	the green part of a tree that uses sunlight, water, and minerals to provide energy to the tree. The leaves of most deciduous trees live only one year.
litter	the layer of dead material, not yet rotted, on top of the forest floor.
mineral soil	soil that has very little dead plant material in it. In a forest, mineral soil is usually below the duff.
needle	leaf of a conifer. Needles contain very busy living cells. Needles usually live three years or longer.
root	the part of a tree that lives underground. Roots collect water and minerals from the soil and carry them into the trunk. Roots also support the tree. Roots have living cells at their tips and under their "bark."
seed	a very tiny, living tree - just waiting to grow - and its protective covering, filled with nutrients. Some seeds have fluffy or scaly "wings" to catch the wind as they fall. The seed needs just the right temperature, water, sunlight, and soil conditions before it can grow.
trunk	the part of a tree that connects leaves and branches in the air to roots in the ground. People often call the trunk of a small tree its "stem."
wood	the strong material inside a tree's bark and cambium that supports the tree and helps carry water from roots to leaves. Wood consists mainly of cells produced in past years that have died and become hollow.

Student handout

Mystery Trees
Species Assignments

Species Name	Code	Students or Team Name
black cottonwood	B	_____
Douglas-fir	V	_____
Engelmann spruce	H	_____
lodgepole pine	E	_____
ponderosa pine	O	_____
quaking aspen	L	_____
subalpine fir	C	_____
western larch	T	_____
whitebark pine	J	_____

Teacher Record

This Tree's No Mystery

Tree Species: _____

Team Members _____

1. Are the leaves broad and flat (more than 1 cm wide) or long and narrow (less than 1/2 cm wide)? _____

2. How long and how wide are the leaves? _____ cm by _____ cm

3. Do the leaves grow in bundles, or do they grow right out of the stem? _____

4. Measure the biggest bud. How wide is it? _____ cm

5. How long is the biggest bud? _____ cm

6. Do the buds have pointy or rounded tips? _____

7. Does the tree produce seeds or cones? _____

8. Describe the seeds or cones -- size, color, how they look: _____ _____

   _____

9. How thick is the bark? _____ cm

10. Describe the bark: _____

12. Does the tree's crown look open? Can you see light through its branches? _____

13. Do the branches reach all the way to the ground? _____

14. Describe other things you have noticed about your tree:

Student handout

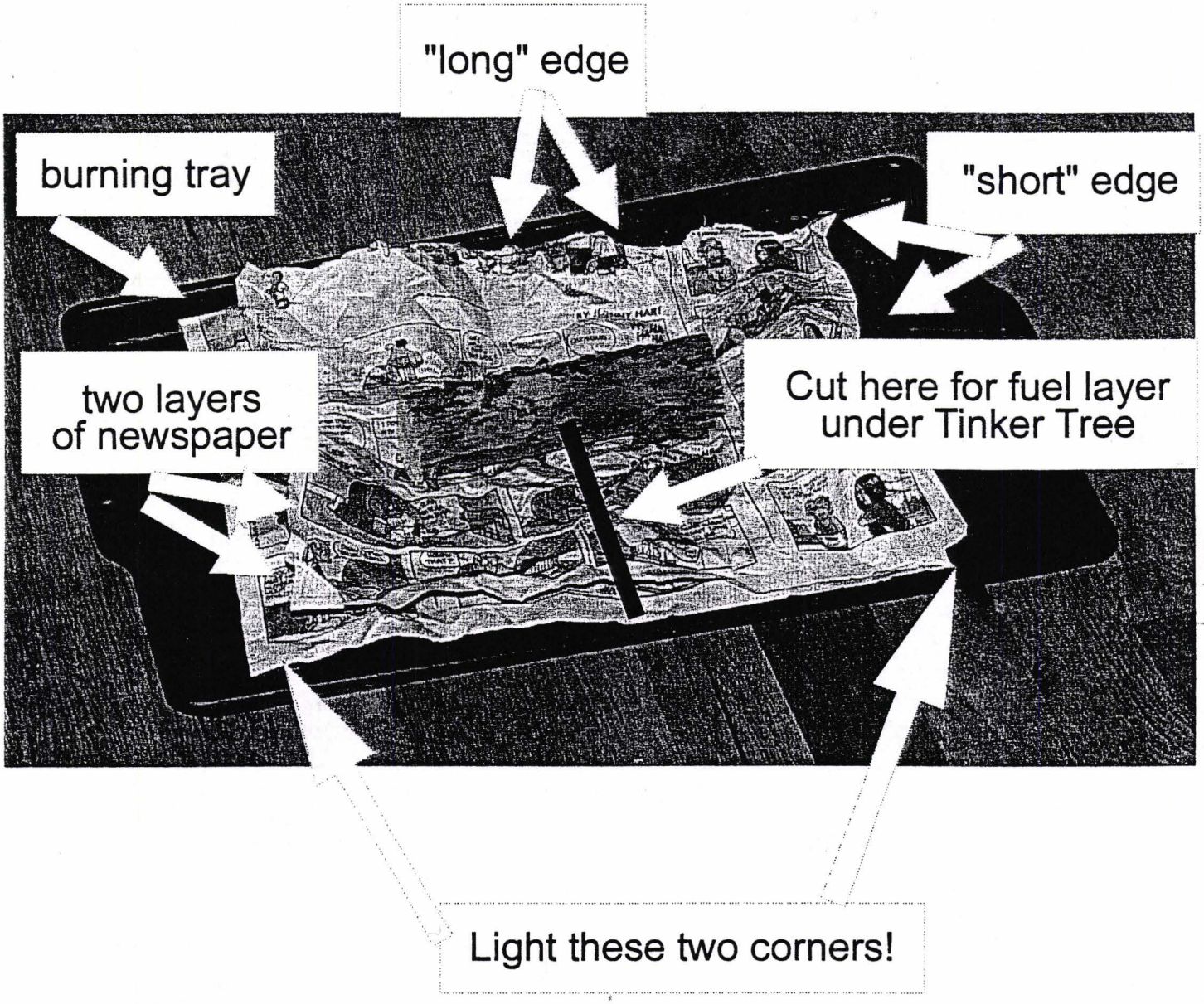
Tree Habitat Information

Here is information about the trees that grow on Sasquatch Peak and along Footprint Creek in the Bigfoot National Forest, which is somewhere in the northern Rocky Mountains or the Intermountain area. The valley bottom along Footprint Creek is at 900 m elevation. The summit of Sasquatch Peak is at 3000 m.

Tree Species	Elevations where this species is most common (m above sea level)	Need for moisture
Black cottonwood	900-1400	high
Douglas-fir	900-2000	low to medium
Engelmann spruce	1300-2400	medium to high
Grand fir	900-1700	medium to high
Lodgepole pine	1500-2300	low to medium
Quaking aspen	900-1900	medium to high
Ponderosa pine	900-1700	low
Subalpine fir	1400-2500	medium
Western larch	900-2000	medium
Whitebark pine	1800-2600	low

Student handout

Setup of burning tray and newspaper fuel for Activities IV-1 and IV-4



Exp 1. Dead vs. Green Needles Names

Organize your team. Everyone should observe the fires. One person should record information on the data sheet AFTER the whole team has talked over what to write.

Procedure:

1. Get 10-20 pine needles from each of the fuel packets "*Dead Ponderosa Pine needles*" and "*Live Ponderosa Pine needles.*" Use what you already know about fire, including the Fire Triangle, to guess which needles will be easier to burn. Write this *hypothesis* below on line 1.
2. Place the burning tray on a flame-retardant surface in a laboratory or on a paved surface outdoors with little wind.
3. Crumple two quarter-page sheets of newspaper into two balls. Flatten them out a bit, so some air gets between the layers. Place them, one on top of the other, on the burning tray.
4. Lightly spread the dead pine needles on top of the newspaper in the burning tray. Scatter them around on the paper; don't leave them in a single pile.
5. Use a match to ignite the two corners of newspaper nearest you. (See illustration.)
6. Observe the fire.
7. Describe how well the dead needles burned on your data sheet, line 2.
8. Shake the burned and partly burned materials into a metal trash can. Spray water on them, if necessary, to put out any smoldering. (Fire is not completely out until there is no smoke.)
9. Repeat steps 3 through 8 with the live ponderosa pine needles. Record observations on line 3.
10. Which needles were **really** harder to burn? Record on line 4.
11. Answer the questions on lines 5 and 6.

1.	**Hypothesis:** Which needles do you think will be easier to burn?	
2.	How well did the **dead needles** burn?	
3.	How well did the **live needles** burn?	
4.	**Which set of needles burned more easily?**	
5.	Was your hypothesis (question 1) correct?	
6.	Try to explain your results. The **Fire Triangle** may help you explain which needles burned more easily.	

Student Handout

Exp 2. Tree Buds Names

Organize your team. Everyone should observe the fires. One person should record information on the data sheet AFTER the whole team has talked over what to write.

Procedure:

1. Get one of the small branches from the "*Ponderosa Pine Buds*" fuel packet and one from the "*Douglas-fir Buds*" fuel packet.
2. Use what you already know about fire to guess which bud will be easier to damage with fire. This is your *hypothesis*. Write it on the data sheet below, line 1.
3. Place the burning tray on a flame-retardant surface in a laboratory or on a paved surface outdoors with little wind.
4. Crumple two quarter-page sheets of newspaper into two balls. Flatten them out but leave room so some air can get between the layers. Place them, one on top of the other, on the burning tray.
5. Place the two tree buds on top of the newspaper in the burning tray.
6. Use a match to ignite the two corners of newspaper nearest you (see illustration).
7. Observe the fire.
8. Look at the two burned buds. Try to scrape away the burned outside.
9. Answer questions 2-5.
10. Answer questions 6 and 7.

1. **Hypothesis:** Which bud do you think will be easier to damage with fire?	
2. Describe the burned **Douglas-fir** bud.	
3. Do you think the burned **Douglas-fir** bud survived?	
4. Describe the burned **ponderosa pine** bud.	
5. Do you think the burned **ponderosa pine** bud survived?	
6. Was your hypothesis (question #1) correct?	
7. Try to explain your results. The **Fire Triangle** may help.	

Student Handout

Exp 3. Large vs. Small Twigs Names_____

Organize your team. Everyone should observe the fires. One person should record information on the data sheet AFTER the whole team has talked over what to write.

Procedure:

1. Place about a quarter of the contents of two fuel packets "*Large Twigs*" and "*Small Twigs*" on a paper towel. Use what you already know about fire, including the Fire Triangle, to guess which twigs will be easier to burn. Write this *hypothesis* on the data sheet below, line 1.
2. Place the burning tray on a flame-retardant surface in a laboratory or on a paved surface outdoors with little wind.
3. Crumple two quarter-page sheets of newspaper into two balls. Flatten them out a bit, so some air gets between the layers. Place them, one on top of the other, on the burning tray.
4. Spread the small twigs on top of the newspaper in the burning tray. Spread the twigs around on the paper; don't leave them in a single pile.
5. Use a match to ignite the two corners of newspaper nearest you.
6. Observe the fire.
7. Describe how well the twigs burned on your data sheet, line 2.
8. Shake the burned and partly burned materials into a metal trash can. Spray water on any smoldering materials. (Fire is not completely out until there is no smoke.)
9. Repeat steps 3 through 8 with the large twigs. Record observations on line 3.
10. Answer the questions on lines 4-6.

1.	**Hypothesis:** Which twigs do you think will be easier to burn?	
2.	How well did the **small twigs** burn?	
3.	How well did the **large twigs** burn?	
4.	**Which twigs burned more easily?**	
5.	Was your hypothesis (question #1) correct?	
6.	Try to explain your results using the **Fire Triangle**.	

Student Handout

Exp 4. Duff vs. Mineral Soil... or... "Root Sandwich"

Names_____

Organize your team. Everyone should observe the fires. One person should record information on the data sheet AFTER the whole team has talked over what to write.

Procedure:

1. Get about a quarter of the contents of two fuel packets, "*Duff*" and "*Mineral Soil.*" Use what you already know about fire, including the Fire Triangle, to guess which material will protect plant roots in the soil better. This is your *hypothesis*. Write it on line 1 below.
2. Place the burning tray on a flame-retardant surface in a laboratory or on a paved surface outdoors with little wind.
3. Crumple two quarter-page sheets of newspaper into balls. Flatten them out a bit but leave room so air can get between the layers. Place them on the burning tray.
4. Cut five pieces of cotton string about 10 cm long. The string represents plant roots. Place it on the newspaper. Sprinkle the duff loosely around the string without covering it completely.
5. Place three layers of newspaper on top of the duff and string. This makes a "root sandwich."
6. Use a match to ignite the two corners of newspaper nearest you.
7. Observe the fire.
8. After the fire goes out, describe the cotton string on line 2 of the data sheet.
9. Shake the burned and partly burned materials into a metal trash can. Spray water on any smoldering materials. (Fire is not completely out until there is no smoke.)
10. Repeat steps 3 through 9 with another piece of cotton string and the mineral soil sample. Record observations on line 3.
11. Answer the questions on lines 4-6.

1.	**Hypothesis:** Will **duff** or **mineral soil** protect plant roots better?	
2.	How well did **duff** protect the "root"?	
3.	How well did **mineral soil** protect the "root"?	
4.	**Which material protected the root better?**	
5.	Was your hypothesis (questions #1) correct?	
6.	Try to explain your results. The **Fire Triangle** may help.	

Student Handout

Temperature at Cambium of Coffee-can Tree

Time	Layers of insulation					
	0	2	4	6	8	10
0						
15						
30						
45						
60 (1 min)						
75						
90						
105						
120 (2 min)						
135						
150						
165						
180 (3 min)						
195						
210						
225						
240 (4 min)						

Data Sheet for Student Recorder

Recipe for a Lodgepole Pine Forest Name_____

Free Seed from Cones

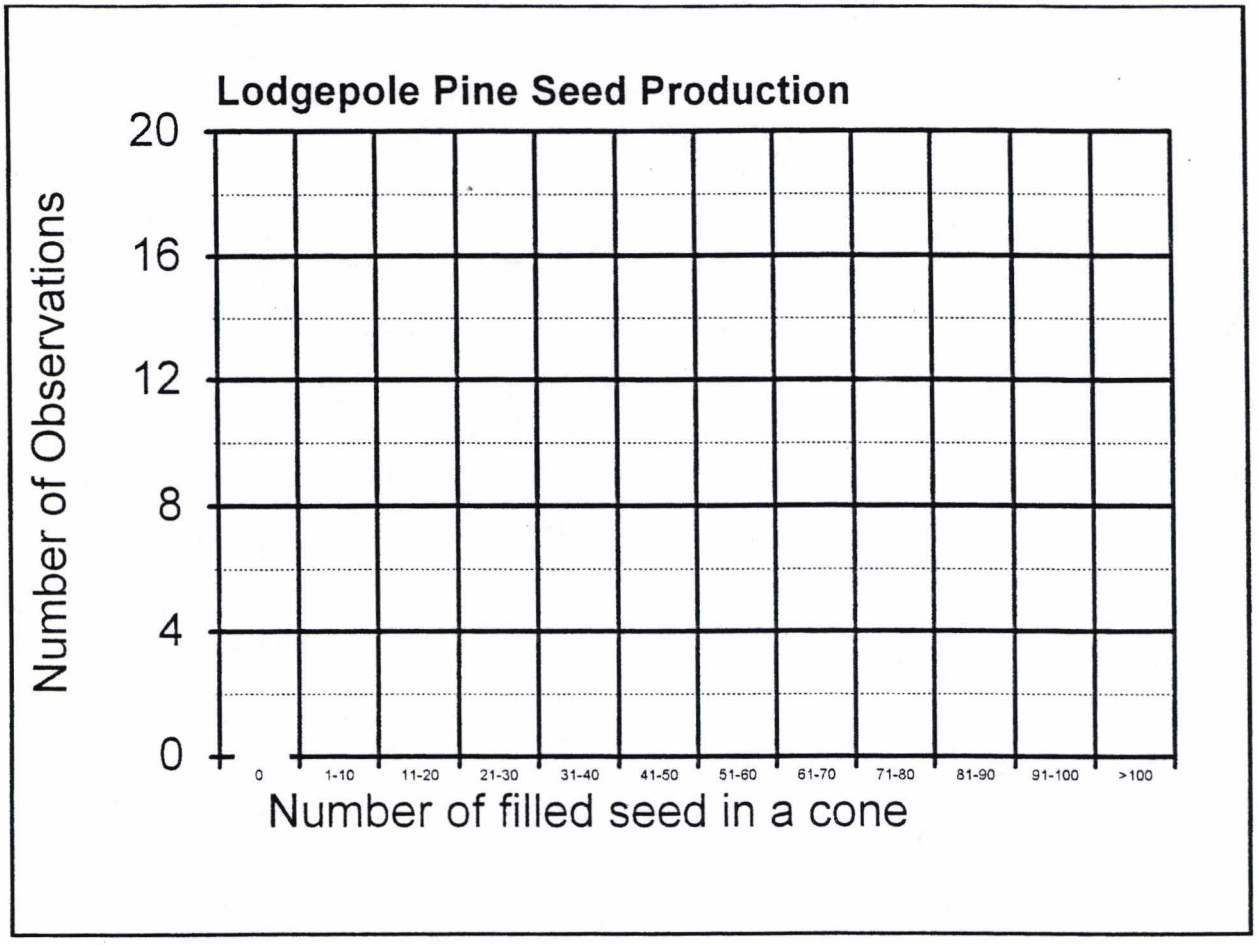
1. Pour boiling water into a shallow pan or pie tin.
2. Place your lodgepole pine cone in the hot water for 20 seconds, then remove with a spoon.
3. Place cones on a napkin and leave in a warm, dry place overnight.
4. Shake and tap each cone over a paper plate to catch the seeds.
   Examine the seeds carefully. Those that are not "filled" (having a rounded brown thing 2 mm or so across attached to the papery wing) contain no tree embryo. Discard them.
5. Count the "filled" seeds from the cone and write the number down.

Forests are very good at growing new pine trees. It is harder to grow them at home, but you can use the directions below to try.

Growing New Trees

1. Rub each filled seed gently to break off its papery "wing."
2. Wrap all seeds in a moist paper towel and place in an unsealed plastic bag.
3. Store in refrigerator for 4 weeks. Keep moist but <u>not wet</u>.
4. Place potting soil 5-10 cm deep on the bottom of a clay pot.
5. Plant seeds in this soil and cover with about 2 mm of soil.
6. Place in a warm, sunny place. Mist with a spray bottle every day or two to keep soil moist <u>but not wet</u>. Wait 4 to 8 weeks for seedlings to emerge.
7. You can plant seedlings outside after the ground has thawed. Sunny, well drained places are best. Seedlings from an artificial environment are fragile, so don't count on survival for your seedlings.

Student Handout



Transparency

Lodgepole Pine Data Name_____

List the number of seeds in each cone. If someone found no filled seed in a cone, record a "0." If most of the trees in a forest are producing no live seed, that's important.

Use the data above to prepare a graph that shows cone productivity. In the table below, tally the number observations that showed zero seed, the number with 1-10 seeds, etc.

Number of seeds per cone	Number of students finding that many seeds per cone
0	
1-10	
11-20	
21-30	
31-40	
41-50	
51-60	
61-70	
71-80	
81-90	
91-100	
more than 100	

Graph your results. Use "Number of observations" along the Y axis and "Number of Seeds per Cone" along the X axis. Draw bars that show the results of your tally.

Student Handout

Lodgepole Pine Challenge **Name**_____

PINE FACTS

- An average lodgepole pine produces 500 to 1,000 cones every year.
- More than half of the cones in a lodgepole pine forest may be resin-sealed.
- Much of the seed in resin-sealed cones stays "viable" (able to grow) for 20 years or more. Some lodgepole pine seed has germinated after 150 years!
- 1,500 to 4,000 lodgepole pine trees may live in a forest area 100 by 100 meters (a "hectare," an area a little larger than a football field).
- Lodgepole pine trees live about 100 to 150 years. Grown trees are often killed by mountain pine beetles or by fire.

ECOLOGY CHALLENGE

Use **your class's data, the facts** above, and **your thinking skills** to answer these questions. If you don't know an answer, think of a way to find out - an experiment - and describe it.

1. How well does hot water, like you used in the experiment, mimic fire?
2. How well does a refrigerator mimic winter?
3. Why do lodgepole pine seeds have wings?
4. How many seeds might be produced by a whole lodgepole pine tree in one year?
5. How many grown lodgepole pines are likely to live in an area the size of your classroom?
6. If a severe fire occurs in a patch of forest as big as your classroom, how many tree seedlings would you probably find the next year?
7. What happens to keep some seedlings from growing into large trees?
8. Why are resin-sealed cones and long-lasting seeds useful traits for lodgepole pine?
9. Ask another question about lodgepole pine. Can you answer it? If not, can you think of ways to find the answer?

Student Handout

Tinker Tree Derby

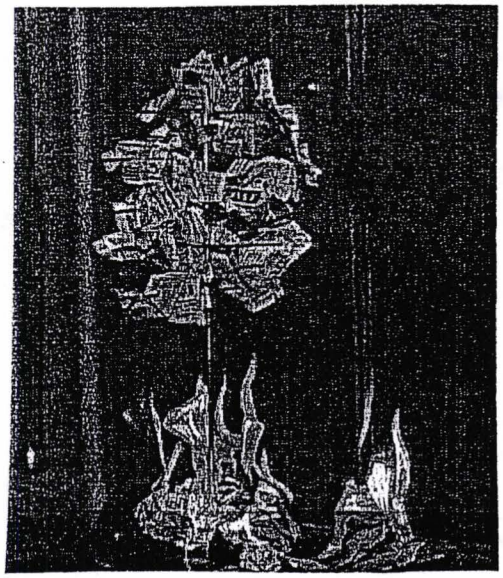
Names_____

Your assignment is to design a model tree, a "tinker tree," that does not burn when a fire passes under it. That could be easy to do. You could just assemble a tree with no leaves. But your tree must have leafy branches on it. The tree with the most length of leafy branches that "survives" underburning wins the Tinker Tree Derby.

Tinker trees are two-dimensional rather than round. A tinker tree's trunk is a support stand. Its branches are rods stuck through holes in the trunk. Its leaves are strips of newspaper.

Procedure:

1. Place a support stand in the center of the burning tray.
2. Crumple two quarter-pages of newspaper into two balls. Flatten them out a bit, but make sure that some air gets between the layers. Cut a line from one edge to the middle, then place the newspaper flat on the support stand base, with the stand at its center. (See photo below.) The newspaper represents surface fuel. Make sure your tinker tree is in the middle of the burning tray and the surface fuel.
3. Slide wire "branches" through the holes in the tinker tree trunk. Arrange these branches in a way that you think will not burn when the newspaper below is burned.
4. Cut about 20 strips of newspaper about 50 cm long and 5 cm wide. Fold them accordion-style. Punch a hole through all layers of each strip. These form your tinker tree foliage.
5. Slide a foliage strip onto each tinker tree branch; for short branches, you may shorten it.



Student Handout

How Tough?
Rank the trees on a scale from 1 to 10, where 10 is the ultimate fire resister!

Species	Bark on old trees	Roots	Architecture		Flammability of foliage	Fire Resistance Score	
			Branches	Forest		Survival	Regeneration
Black cottonwood	thick	shallow	open	open, shrubby	low		
Douglas-fir	very thick	deep	open	moderate to dense	high		
Engelmann spruce	thin	shallow	low, dense	dense	medium		
Grand fir	thick	shallow	low, dense	dense	high		
dgepole pine	very thin	deep	high, open	open to dense	medium		
Quaking aspen	very thin	shallow	open	open	low		
Ponderosa pine	very thick	deep	high, open	open	high		
Subalpine fir	very thin	shallow	very low, dense	moderate to dense	high		
Western larch	very thick	deep	high, very open	open	low		
Whitebark pine	thin	deep	high, open	open	medium		

Student handout, transparency

Designer Tree Rules

Each Tree Designer Team:

1. Draw a Place Card. The card describes the place that you will design a tree for. The place may be at a low or high elevation, and it may have poor or rich soil. The Place Card states how many "sun dollars" you can get for your Designer Tree at the Resource Bank. Some locations have more resources available for plants than others. The Place Card states how many "sun dollars" you can get at the Resource Bank for your location.
2. Visit the Bank. Obtain the money that your Place Card entitles you to.
3. Plan how to use your sun dollars to buy Tree Traits. Your Designer Tree should be able to survive the kinds of fires likely in your special place, or it should be able to reproduce well after fires, or both.
4. As you plan your budget or after you finish it, visit the Tree Store to buy Trait Cards.
5. You can return any Trait Card to the bank for a refund. The Banker may charge you extra for this service.
6. You can trade or buy Trait Cards from other teams. You can bargain, but both teams have to agree on the price.
7. When you have finished buying and bargaining for Traits, draw a diagram of your Designer Tree in your special Place. Include all the information from your Place Card and label every Trait that you bought or traded for on your tree.
8. Present and explain your Designer Tree to the class.

Student Handout

Tree Story Data

Name___ _____

Complete these questions to discover the secrets of your tree.

1. Does your tree cookie contain a tiny ring at the center (the "pith"), or is the pith missing on your cookie?

   _____

   If the pith is present, how many years went by before your tree was first scarred by fire?

   _____

2. A tree may survive several fires in its lifetime. After the first scar is formed, later fires may scar only one side of the tree or both.

   a. How many fires have burned your tree? _____

   b. How long were the intervals between fires? _____ _____

   _____ _____ _____ _____ _____ _____ _____

   c. What is the average interval between fires? _____ years

3. a. How long has it been since your tree's last fire scar? _____ years

   b. Is this interval very different from the average in 2(c)? If it is, try to explain why.

_____

_____

4. Wide tree rings indicate good growth years, when moisture, sunlight, and nutrients were plentiful to the tree. Rings that are very close together may indicate years of drought, disease, injury, shading, or crowding by other trees.

   a. What time period was the best for your tree's growth?

   _____

   b. During what time period did your tree grow most slowly?

   _____

   c. Were the years right after fire usually good or poor for growth?

   _____

   How would you explain that?

   _____

   _____

5. Do you think your tree could be damaged by **lack** of fire? Explain.

_____

_____

6. Estimate the year when your tree's first fire scar formed. What do you think your school ground looked like in that year? Write a paragraph or draw a picture.

Forest Stories: Repeating Themselves?

Ponderosa pine		Lodgepole and Whitebark pine	
Your Initials	*Average Interval between Fires (yr)*	*Your Initials*	*Average Interval between Fires (yr)*
Number:		*Number:*	
Sum:		*Sum:*	
Average:		*Average:*	

Teacher Record

Your Forest Ecosystem: **Ponderosa pine/Douglas-fir**

Character	*Name*
Interviewer	
Ponderosa pine	
Douglas-fir	
Pinegrass	
Serviceberry	
Arrowleaf balsamroot	
Armillaria root rot	
Douglas-fir mistletoe	
Pileated Woodpecker	
Elk*	
Flammulated Owl	
Red-backed vole*	
Pine marten*	

Your Goal: Prepare a 15-minute play that shows the audience how your kind of forest has changed over the past 100 years.

Steps:

1. Figure out who will play each role in the list of characters above. Some actors may play more than one role. The asterisks mean that you will have to share that organism with other forest types. In your play, the interviewer talks with the forest inhabitants about how the forest looks now-- this year. Then the interviewer asks them to reminisce and use a "flashback" to show how the forest looked 100 years ago, soon after a fire. (You must decide what kind of fire occurred; you may show it in your play, if you wish.) Have the interviewer ask about the years around 1950, and use another flashback to show the forest then. You may change masks to depict changes in the characters over time.
2. Learn about forest succession. Look at the *Pathways in Time* booklet and the feltboard kit narrative (*Creepy, Crawly Fires*) for your forest community to find out what the land looked like after fires in the past, then 50 and 100 years after fire.
3. Learn about your characters. Get the pages from the *FireWorks Notebook* that describe your characters. Learn what each one looks like, where it likes to live, and how it "makes its living" in the forest. Find out if it prefers to live in a forest just after fire or many years after fire. If it is present all the time, find out if it changes as the forest changes over time. You may need more than one mask to show that.
4. Write and practice your play. Make sure that you set aside one area in your forest that has moist, old forest-- maybe a deep canyon or a north-facing slope. This area will burn very infrequently or not at all. Make your masks.
5. Perform for an audience. After your play is done, allow a few minutes for audience members to ask questions about your forest.

Team Handout

Your Forest Ecosystem: **Lodgepole pine/subalpine fir**

Character	*Name*
Interviewer or Narrator	
Lodgepole pine	
Subalpine fir*	
Beargrass	
Blue huckleberry	
Glacier lily	
Mountain pine beetle	
Fireweed	
Black-backed woodpecker	
Elk*	
Pine marten*	
Red-backed vole*	

Your Goal: Prepare a 15-minute play that shows the audience how your kind of forest has changed over the past 100 years.

Steps:

1. Figure out who will play each role in the list of characters above. Some actors may play more than one role. The asterisks mean that you will have to share that organism with other forest types. In your play, the interviewer talks with the forest inhabitants about how the forest looks now-- this year. Then the interviewer asks them to reminisce and use a "flashback" to show how the forest looked 100 years ago, soon after a fire. (You must decide what kind of fire occurred; you may show it in your play, if you wish.) Have the interviewer ask about the years around 1950, and use another flashback to show the forest then. You may change masks to depict changes in the characters over time.
2. Learn about forest succession. Look at the *Pathways in Time* booklet and the feltboard kit narrative (*Roaring Fires*) for your forest community to find out what the land looked like after fires in the past, then 50 and 100 years after fire.
3. Learn about your characters. Get the pages from the *FireWorks Notebook* that describe your characters. Learn what each one looks like, where it likes to live, and how it "makes its living" in the forest. Find out if it prefers to live in a forest just after fire or many years after fire. If it is present all the time, find out if it changes as the forest changes over time. You may need more than one mask to show that.
4. Write and practice your play. Make sure that you set aside one area in your forest that has moist, old forest-- maybe a deep canyon or a north-facing slope. This area will burn very infrequently or not at all. Make your masks.
5. Perform for an audience. After your play is done, allow a few minutes for audience members to ask questions about your forest.

Team Handout

Your Forest Ecosystem: **Whitebark pine/subalpine fir**

Character	*Name*
Interviewer	
Whitebark pine	
Subalpine fir*	
Smooth woodrush	
Grouse whortleberry	
Red squirrel	
White pine blister rust	
Mountain pine beetle	
Clark's nutcracker	
Elk*	
Grizzly bear	
Red-backed vole*	
Pine marten*	

Your Goal: Prepare a 15-minute play that shows the audience how your kind of forest has changed over the past 100 years.

Steps:

1. Figure out who will play each role in the list of characters above. Some actors may play more than one role. The asterisks mean that you will have to share that organism with other forest types. In your play, the interviewer talks with the forest inhabitants about how the forest looks now-- this year. Then the interviewer asks them to reminisce and use a "flashback" to show how the forest looked 100 years ago, soon after a fire. (You must decide what kind of fire occurred; you may show it in your play, if you wish.) Have the interviewer ask about the years around 1950, and use another flashback to show the forest then. You may change masks to depict changes in the characters over time.
2. Learn about forest succession. Look at the *Pathways in Time* booklet and the feltboard kit narrative (*Rollercoaster Fires*) for your forest community to find out what the land looked like after fires in the past, then 50 and 100 years after fire.
3. Learn about your characters. Get the pages from the *FireWorks Notebook* that describe your characters. Learn what each one looks like, where it likes to live, and how it "makes its living" in the forest. Find out if it prefers to live in a forest just after fire or many years after fire. If it is present all the time, find out if it changes as the forest changes over time. You may need more than one mask to show that.
4. Write and practice your play. Make sure that you set aside one area in your forest that has moist, old forest-- maybe a deep canyon or a north-facing slope. This area will burn very infrequently or not at all. Make your masks.
5. Perform for an audience. After your play is done, allow a few minutes for audience members to ask questions about your forest.

Team Handout

Puzzle Strategy

These are the pieces of three jigsaw puzzles that tell the story of three pine forests and some of their residents. There are probably thousands of ways to assemble the puzzles. If you get stuck, try the following steps:

1. Find the three circular pieces and set them out on the table. These three "medallions" show the kinds of pine that the puzzles describe.

2. Sort the remaining pieces by shape. There should be three identically shaped pieces for the upper right corner, for example.

3. Work with one set of three like-shaped pieces at a time. For each set, use what you already know about fire and forests, and read new information, to decide which piece goes with each pine species. Set it next to the correct medallion piece. (Of course, you really need to figure out only two pieces in any set of three; the third you can figure out by the process of elimination.)

4. Assemble the three puzzles.

Student Handout

What Do You Think? *Name* _____

Look at your two responses to Visiting with Wildland Fire.

1. What responses are the same?

_____

_____

_____

2. What responses are different?

_____

_____

_____

3. Circle one of your feelings that has changed. Can you explain why? Is there any particular information that changed your response? If no feelings have changed, can you explain why?

_____

_____

_____

_____

_____

_____

Student Handout

This Tree's No Mystery

Tree Species: _____

Team Members _____

1. Draw a leaf or needle from your tree.

2. Measure two leaves. How long are they? _____ cm and _____ cm

3. Do the leaves grow right out of the twig,
   or do they grow in little bunches? _____

4. If the leaves are in bunches, how many are in each bunch? _____

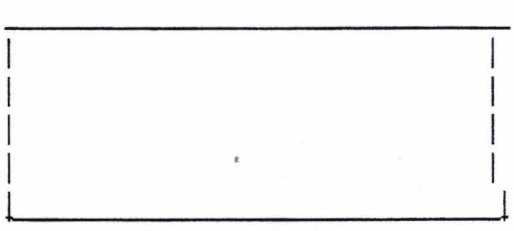
5. Are the buds (at the ends of the twigs) pointy or rounded? _____

6. Draw a flower or cone from your tree.

7. If the tree produces cones, are they stiff or papery? _____

8. How thick is your tree's bark? _____ cm

9. Color the box like your tree's bark.



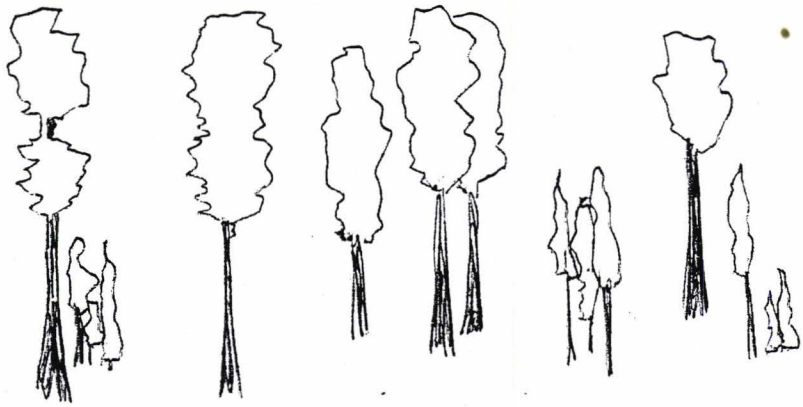
10. Describe other things you notice about your tree:

Student handout

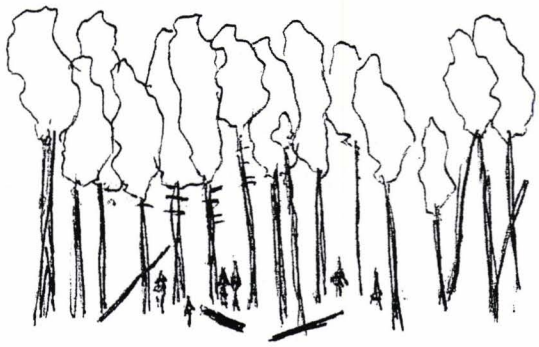
What Kind of Fire? Name:_____

Sketch two or three trees from each kind of forest. Draw a typical fire in that forest.

Ponderosa Pine



Lodgepole Pine



Whitebark Pine

Student Handout

Buried Treasure **Name:** _____

1. In the space below, draw the outline of your bulb, with its pointy tip at the top of the drawing.

2. Look for the tiny plant in the middle, near the bottom of the bulb. Draw it inside your outline.

3. Look for the thick leaves wrapped around the tiny plant. Draw them inside your outline, too.

4. Pull some of the leaves off and feel them. How are they similar to aboveground leaves?

_____

_____

5. How are they different from aboveground leaves?

_____

_____

Student Handout

Communities in Action! Assignment list

Forest Inhabitant	Community*	Student Name
American marten	moist, old-- especially fir	
Armillaria root rot	PP-- favors Douglas-fir trees	
Arrowleaf balsamroot	PP	
Beargrass	LP, WB	
Black-backed woodpecker	LP	
Clark's nutcracker	WB	
Douglas-fir	mainly PP	
Douglas-fir mistletoe	mainly PP-- favors Douglas-fir trees	
Elk	all	
Fireweed	mainly LP	
Flammulated owl	PP	
Glacier lily	LP, WB	
Grizzly bear	WB, LP	
Grouse whortleberry	WB	
Lodgepole pine	LP	
Mountain pine beetle	mainly LP	
Pileated woodpecker	PP	
Pinegrass	mainly PP	
Ponderosa pine	PP	

Red squirrel	all, but be sure to show in WB	
Red-backed vole	old, moist--especially fir	
Saskatoon serviceberry	PP, LP	
Smooth woodrush	WB	
Subalpine fir	LP, WB	
White pine blister rust	WB	
Whitebark pine	WB	

* PP=ponderosa pine/Douglas-fir; LP=lodgepole pine/subalpine fir; WB=whitebark pine/subalpine fir.

Teacher Record

Communities in Action!

Name _____

As you study your forest inhabitant (a plant, animal, or fungus), try to answer these questions. You will need the answers for "In the Web" and "Drama in the Forest."

1. What is the name of your plant or animal or fungus? _____

2. Where does it get its energy from?

   _____

   _____

3. Who gets energy from it?

   _____

   _____

4. What kinds of trees usually live in its neighborhood?

   _____

   _____

5. Does it live best in places burned by surface fire, crown fire, or no fire? Or doesn't it matter?

   _____

6. Does it matter to this forest inhabitant how long ago the last fire was? Explain.

   _____

   _____

Student Handour

"Communities in Action!" Script

Here is the general story line for your "Communities in Action!" play. Four kinds of forest will be or in your classroom or on your stage-- ponderosa pine (PP). lodgepole pine (LP), whitebark pine (WB), and a moist, very old forest (OF, which burns very seldom, so animals can usually hide there as other parts of the forest burn). The teacher or a narrator will follow this "script." Each time your forest inhabitant or community is mentioned, your group will show or describe the "community in action" at that particular time.

Scene	Narrator's Script	Place*	Hints for actors and actresses
1	It is the year 1800. Look at this ***old ponderosa pine forest***.	PP	Who lived in a typical old forest in those years?
2	A fire burns through.	PP	What kind of fire was typical in ponderosa pine forests 200 years ago?
3	Look at each of the plants! How can they ever come back?	PP	Plants and fungi, show growing points that have survived. Show where your seeds are.
4	Will any of the animals have to move away because of the fire?	PP, OF	Animals, did the fire change your habitat so you can't live here?
5	Fire burns here about every 20 years until 1900.	PP	What kind of fire?
6	It is 1889. Look at this ***old lodgepole pine forest***. I don't think it has burned in 200 years.	LP	Who lives here-- plants and animals? Are any trees killed by pine beetles?
7	This is a very dry summer. A fire burns through.	LP	What kind of fire is typical in old lodgepole pine forests?
8	Look at the plants! How can they ever come back?	LP	Plants, show growing points that have survived. Show where your seeds are.
9	Will any of the animals have to move away because of the fire? Will any new animals arrive?	LP, OF	Animals, did the fire change your habitat so you can't live here-- or is this now your favorite place to live?
10	It is still 1889. Look at this ***old whitebark pine forest*** on a ridge top.	WB	Who lives here-- plants and animals. Has the blister rust fungus arrived yet?

11	The 1889 fire moves uphill from the lodgepole forest to the ***whitebark pine forest***.	LP, WB	What kind of fire is typical here? Does it burn all of the tree crowns, or none, or some?
12	Look at the plants! How can they come back?	WB	Plants, show growing points that have survived. Show where your seeds are.
13	Will any of the animals have to move away because of the fire?	WB, OF	Animals, did the fire change your habitat so you can't live here?
14	Go back to the ***lodgepole pine forest*** in 1910. How has it changed?	LP	Who lives here now? How big are the trees? Is it a favorite place for any of the animals?
15	Now it is 1990. Fire has not visited the ***ponderosa pine forest*** in 101 years. How has it changed?	PP	Are most of the trees pines or Douglas-firs? Is there more mistletoe or root rot than there was in 1800?
16	If a fire visits now, what will it look like?	PP	Think about the "tinker trees." What kind of fire would you expect in this kind of forest now?
17	It is still 1990, and the ***lodgepole pine forest*** has not burned either. What does it look like?	LP	Who lives here now?
18	The ***whitebark pine forest*** hasn't burned in 101 years either. What has changed?	WB	A visiting fungus has changed many things. Can you show how?
19	What you would like your forest to look like when you get old, in about the year 2050? ***Ponderosa pine*** ***Lodgepole pine*** ***Whitebark pine***	PP LP WB	Talk this over in groups. You can try to show one kind of forest, or you can try to show (or describe in words) different patches with different inhabitants.

PP=ponderosa pine/Douglas-fir forest, LP=lodgepole pine/subalpine fir, WB=whitebark pine/subalpine fir, OF=old, moist forest.

Safety in Fire's Homeland

Name(s)_____

Checklist for Photo Number: _____

A. Put a check in the "yes," "no," or "can't tell" column.

		Yes!	No!	Can't tell
	About the House:			
1	Is the roof metal or shingle?			
2	Is firewood and other wood stored away from the house, not touching walls or deck?			
3	Are weeds cleared away from the sides of the house?			
4	Are tree limbs cleared away from roof and chimney?			
5	Are dead leaves and needles cleaned from roof and rain gutters?			
	Around the House (safety zone, within 10 m):			
6	Are trees and shrubs 5 m apart or more?			
	Are "ladder fuels" and low branches cleared from underneath big trees?			
8	Is the lawn kept green, even in late summer?			
9	If the house is at the top of a slope, is the *safety zone* bigger, 30 m or more?			
	About the Location:			
10	Is the house on a flat place, set back from the top of a slope?			
11	Is the road wide enough for a car going out to pass a fire engine going in?			
	B. Count the checks in each column:			

C. Write a letter to the home owner. Explain your observations. If you think the home's safety needs improvement, tell the home owner how to improve it.

Student Handout

Trunk Number

FireWorks Trunk Materials

Item		Quantity	Checked In
Ashtray for burnt matches		4	
Beaker, 500 mL		8	
Candle, votive		4	
Clamp for chemistry support stand		4	
Coffee can (1.5 lb)		1	
Cookie sheet ("burning tray")		4	
Feltboard kit for Lodgepole Pine forest		1	
Feltboard kit for Mystery Trees		1	
Feltboard kit for Ponderosa Pine forest		1	
Feltboard kit for Whitebark Pine forest		1	
Fire extinguisher		1	
FireWorks Library		1 box	
Freezer container, 1 qt size		4	
Fuels box (materials in here need not be returned)		1	
Goggles, safety		4 pair	
Hair dryer		1	
Hand lenses		10	
Matchstick Forest Kit	Masonite boards, square, drilled (4)	1 kit	
	3 bolts (1 long), 3 nuts, 3 washers		
	1 nail		

Measuring tape		1	
"Mystery Trees" Materials		1	
Oven mitt		4	
Pins (10) in film canister		1 canister	
Posters	Ancient tree	1	
	Fire Triangle	1	
	Fire Safety	1	
	Tree Portrait	1	
	80 Years of Change	1	
Rod segments with alligator clips		4	
Rulers, plastic, 15 cm		10	
Shadow box with grass specimen		1	
Slide Carousel	"Visiting Wildland Fire" slides	set of 21	
	"You Decide!" Smoke Impact slides	set of 5	
	"Wildland Homes" slides	set of 10	
Spray bottle		2	
String		1 ball	
Support Stand Box	Chemistry support stand box: includes post, base, & about 20 rod segments	4	
Teacher Box		1	
Thermometer, digital		1	
Tree cones box (specimens from 6 species)		1	
Tree cookies (1 unscarred, 1 "challenge", 10 for main activity)		12	
"Tree Skin" insulation (1 plain & 5 quilted pieces)		1 set	
Tree trunk sections		8	

Trunk Number

FireWorks Library

Title	Quantity	Checked In
Book of Fire	1	
Discover magazine: see pp. 100-115: "Heaven's New Fires"	1	
Evergreen magazine-- whole issue: "Montana's Forests: Paradise Lost or Paradise Found"	1	
Field Guide to Forest Plants of northern Idaho	1	
Fire and the Changing Land	1	
Fire, a Force of Nature	1	
Fire Ecology of the Forest Habitat Types of Northern Idaho	1	
Fire in Florida's Ecosystems	1	
Fire in Western Montana's Ecosystems	1	
Fire Protection Guidelines booklet	1	
FireWorks Notebook	1	
Graced by Pines	1	
"Is Smokey Wrong?" article	1	
Legends of Earth, Air, Fire and Water	1	
Made for Each Other (Clark's Nutcracker)	1	
National Geographic: pp. 116-139, "The Essential Element of Fire"	1	

National Geographic: pp. 255-273, "The Great Yellowstone Fires"	1	
"Pathways in Time" booklet-- Ponderosa Pine	1	
"Pathways in Time" booklet-- Lodgepole Pine	1	
"Pathways in Time" booklet-- Whitebark Pine	1	
Plant Survival	1	
Protecting your Home from Wildfire booklet	1	
Rocky Mountain Tree Finder	1	
Wildfire	1	
Yellowstone on Fire	1	

Trunk Number

FireWorks Teacher Box

Title		Quantity	Checked In
Branching Out to the Youth of America		1	
"Bucket Brigade" materials		1	
"Designer Trees" Game		1	
Ecosystem Matters curriculum		1	
Fire Ecology Resource Management Education Unit		1	
FireWorks Cookie Book		1	
FireWorks Curriculum		1	
"Fuels... Tree & Soil Parts, and Fire Targets" Labels		1	
Investigating Your Environment lessons		1	
"Puzzling It Out"-- 4 puzzle sets		1	
"Tinker Trees" Badges & Rosettes		4 each	
Videotapes	"Fire and Wildlife"	1	
	"Science Links Module 2: Wildfire!"	1	
	"Unfinished Song"	1	
	"Yellowstone Aflame"	1	
Visual Aids & Handouts-- looseleaf notebook		1	
Woodsy Owl Activity Guide		1	
"You Decide!" brochures, 5 per set		set of 5	
"ZIP Game" box		1	

Trunk Number

Fuels Box

Materials in this box need not be returned.

Item	No. packages*	Check
Dead, dry needles of ponderosa pine	1	
Green needles of ponderosa pine	1	
Bud & branch tip of Douglas-fir	1	
Bud & branch tip of ponderosa pine	1	
Fine branches (< 1/2 cm thick)	1	
Thick branches (> 2 cm thick)	1	
Duff (peat)	1	
Mineral soil (sand)	1	
Lodgepole pine cones (35 per bag)	1 bag	

* Each package should contain enough for 4 teams to complete the experiment.

Appendix 2
Other Curricula for Teaching about Wildand Fire

Amazing Blazes! A three-hour field experience for 5th and 6th graders with a classroom introduction. From the Tinderbox Project, developed by Ashley Emerson for The Glacier Institute and the U.S.D.A. Forest Service. Contact The Glacier Institute, P.O. Box 7457, Kalispell, MT 59904

Branching Out to the Youth of America[1] , publication NE/NA-116R-96. Northeastern Station and Area, U.S.D.A. Forest Service.

Ecosystem Matters[1] Activity and Resource Guide for Environmental Educators, produced in January 1995 by Rocky Mountain Region, U.S.D.A. Forest Service. Project Manager: Pattyanne Corsentino. U.S. Government Printing Office:1995-577-064.

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Science Links Module 2, developed by the Agency for Instructional Technology and South-Western Educational Publishing, 1800 N. Stonelake Drive, Bloomington, IN 47402

The Role of Fire in Alaska, Fire Information and Resource Education. Produced in 1995 by U.S. Fish and Wildlife Service, 1011 E. Tudor Road, Anchorage, AK 99503

Wildfire Classroom Activities, Fire Education Activities for Grades 6-9. Written by Barbara MacGregor, One World Environmental Education Services. Produced in November 1994 by Washington State Department of Natural Resources. Phone 360-902-1027 for further information.

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[1]in the *FireWorks Library* or *Teacher Box*

Appendix 3
Evaluation

Student Evaluation

Here are a few questions for discussion or tests about *FireWorks*. We will expand this section using questions that pilot teachers provide.

I. Visiting Wildland Fire

II. How Does Fire Work?

III. Neighborhood Trees

1. You have relatives visiting from out-of-state. Select one kind of tree that lives in the forests near your home, and explain to them how to identify it. Use drawings, if you wish.

IV. Tough Trees

2. Your relatives have read in the newspaper that "the forests of the West are burning up." Select one kind of tree (perhaps the same one you used in #3.) Explain how underburns affect this tree, and then how severe crown fires affect it.

V. Tree Stories

VI. Enlarging the Picture

VII. People in Fire's Homeland

3. You have been hired by the U.S. Forest Service to work at an information desk for visitors. During the fall, when Forest employees are conducting prescribed burns, many visitors ask you why there is smoke in the air and if they will be safe camping in the Forest. Explain why the burns are taking place.

Teacher Assessment of *FireWorks*

1. With what grades/groups did you use *FireWorks*?

2. How much time did each group of students spend with *FireWorks*?

3. What is the **most useful** investigation in *FireWorks*? Why?

4. What is the **least useful** investigation in *FireWorks*? Why?

5. What changes do you suggest to the **content** of *FireWorks*?

6. What changes do you suggest to the **format** of *FireWorks*?

7. What other changes do you suggest?

Teacher Assessment
of Specific *FireWorks* Activity

Activity: _____

1. Student grade level:

2. Number of classes, number of students in each:

3. Total time used for this activity with each class:

4. Level of student enthusiasm for this activity:

5. Student comments or questions during the activity:

6. How well did this activity meet the "skills" objectives for the topic?

7. How well did this activity meet the "understanding" objectives for the topic?

8. How could this activity be changed to improve it?